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PRELIMINARY STUDIES ON THE FLOWERING AND SEEDING OF ONIONS IN THE PHILIPPINES: I

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FOUR PLATES

Since the successful introduction of the Bermuda onion into these Islands there has been a need for Philippine-grown onion seed. Onion seed production under local conditions has many benefits. It establishes the industry more firmly in this country. It influences the control of onion pests and diseases, and the breeding of the types desired to suit local conditions and demands. Thus, the present study is an endeavor to find if the big-bulbed (Bermuda) onions with and without treatment would produce flower and seed under Philippine conditions. Incidentally, it is also a study of the onion flower and its pollination.

Let it be said that the production of onion seed "is a two-year process, and two crops are constantly to be cared for" (1930). Plants from seeds very seldom, if at all, produce any seed during the first year. The common practice in the United States is to produce "mother bulbs" from seeds during summer. These "mother bulbs" are stored over winter and then planted the following spring for the production of seed. In the meantime another set of mother bulbs is raised for the following year so as to have a crop of seed every year. "Mother bulbs" are well matured bulbs of medium size. These are produced by

planting the onion seeds or seedlings rather thickly in the field. According to Beattie (1930) bulbs about 3.75 to 5.0 cm. in diameter are the best for seed production.

The popular belief is that the big-bulbed onions do not flower under local conditions. The writers, however, have heard claims that imported onion bulbs have produced flowers; and the senior author, while stationed at Baguio Semi-Temperate Fruit Station, Baguio, Mountain Province (1931–1932), was able to produce two flowering stalks from Red Creole onion produced locally, although these stalks did not produce seeds.

The present study was undertaken at the Lipa Coffee-Citrus Station, Lipa, Batangas; at the Central Experiment Station, Malate, Manila; and at the Los Baños Economic Garden, Los Baños, Laguna. The data herewith presented represent results obtained from May, 1933, to April, 1935.

MATERIALS AND METHOD

Six varieties of big-bulbed onions were used in this study. The varieties used were Yellow Bermuda, Red Bermuda, Red Globe, Red Brown Bombay, White Bombay, Saede, and Beheri. The seeds of Yellow Bermuda and Red Bermuda were imported from the Canary Islands, those of Red Globe, Red Brown Bombay and White Bombay from India, and those of Saede and Beheri from Egypt. The bulbs treated for seed production were raised in the Philippines.

In the 1933 test which was conducted at the Lipa Coffee-Citrus Station, Lipa, Batangas, Yellow Bermuda and Red Bermuda were the only varieties used. The problem was to determine whether the flowering and ultimately the seeding of onion was influenced by the different climatic conditions during the year. Therefore, onion bulbs were planted monthly beginning with the month of June until October, 1933, when the supply of bulbs for planting was already exhausted.

With the 1933–1934 onion crop as material, the study was pursued from a new angle. The practice in the United States to store onion bulbs for seed production over winter at 45°F. (1930) and the publication by Gates (1933) of the finding of Dr. David Griffith on storing bulbs at different temperatures during summer gave the senior author the suggestion to "winter" [1] one-half of the bulbs intended for the study before

[1] The bulbs were kept in cold storage at a temperature of about 10° C. for a period of 1 to 2 months.

planting. This phase of the work was conducted at the Central Experiment Station, Malate, Manila. The "wintered" bulbs were planted side by side with similar bulbs stored under laboratory conditions. This study was undertaken from May to September, 1934. The findings of Dr. Griffith were tried on various bulbs "and the magic 50-degree (F) storage throughout the summer puts them all ready to grow and bloom in a month . . ."

Another set of study, on a larger scale, on the effect of "wintering" of onion bulbs before planting was conducted at the Los Baños Economic Garden, Los Baños, Laguna from October, 1934, to April, 1935. This study furnished the greater part of the data presented in this paper.

In this study, the same six varieties used in Manila were used, and each variety was represented by "wintered" and "non-wintered" bulbs. The bulbs were mostly the harvest from the previous study at the Central Experiment Station in Manila.[2] The observations and studies were mainly, (1) on the effect of "wintering" onion bulbs on their ability to produce flowers and seeds, and (2) on the morphology of the flower, the relative longevity of its stamens and stigma, and its pollination.

EXPERIMENTS AND RESULTS

In this paper, results of studies from May, 1933, to April, 1935, on the flowering and seeding of the big-bulbed onions are presented. The result thus far obtained is very encouraging and it indicates an avenue by which onion for local production may be improved.

A brief study of the onion flower and its pollination was made. Table 1 gives some data on the opening of the onion flower at different times of the day while Table 2 presents some information on the relative longevity of the stamens and stigma of a single flower. Table 3 on the other hand gives some figures on the number of flowers in an inflorescence while Table 4 presents some data on the relative number of seeds developing from one flower of different varieties. Table 5 gives some data on the per cent of seeding of individual flowers bagged before opening.

Table 6 presents the result of the monthly plantings of onion at the Lipa Coffee-Citrus Station. In this study no sign of

[2] Being a rainy season crop, the bulbs were of small size, ranging from 1.5 to 3.0 cm. in diameter.

TABLE 1.—*Showing the number of onion flowers (Red Globe) that opened at different times of the day per inflorescence*

Date	Time of the day				
	night 6–6	6–9 a. m.	9–12 a. m.	12–3 p. m.	3–6 p. m.
22-III-35	12	7	17	4	8
23-III-35	8	10	23	3	1
24-III-35	11	16	11	5	6
25-III-35	22	14	7	10	0
26-III-35	12	15	6	3	0

TABLE 2.—*Showing the relative longevity of the stamens of the onion flower*

Flower number	Length of time from opening of flower to—							
	Dehiscence of inner whorl of stamens		Appearance of outer whorl of stamens		Dehiscence of outer whorl of stamens		Wilting of stamens	
	Hrs.	*min.*	*Hrs.*	*min.*	*Hrs.*	*min.*	*Hrs.*	*min.*
1	8	30	3	0	23	0	48	0
2	5	30	3	30	21	45	46	30
3	5	0	3	5	18	35	46	0
4	8	0	3	30	23	30	51	0
5	7	10	3	50	21	15	51	30
6	5	0	2	30	19	40	50	0
7	5	26	1	56	28	0	58	56
8	5	46	1	55	28	45	52	10
9	8	15	3	45	24	30	56	0
10	7	5	4	10	23	20	59	0
11	4	25	3	55	18	10	55	20
12	4	55	4	0	18	30	29	40
13	4	25	5	5	17	20	31	15
14	6	10	3	5	22	25	32	30
15	7	0	0	20	17	14	25	0
16	5	0	2	50	17	40	29	0
17	9	0	4	0	14	0	42	0
18	7	5	2	5	22	30	34	30
19	6	20	2	10	23	0	31	15
20	7	0	6	0	23	40	51	40
Average	6	21	3	16	21	20	44	4

flowering was observed on the two varieties of Bermuda onion tested.

Table 7 is a summary of the results of the preliminary study on the effect of "wintering" the mother bulb before planting at the Central Experiment Station, Manila. With most of the varieties used in this experiment, the wintered bulbs produced flowers when tested. Bermuda onion nevertheless, did not show

TABLE 3.—*Showing the relative number of flowers in an inflorescence of different varieties of onion*

Umbel number	Variety names			
	Red Globe	Red Brown Bombay	White Bombay	Yellow Bermuda
1	118	156	128	68
2	195	136	38	40
3	184	145	50	38
4	105	234	45	102
5	172	197	70	46
6	124	160	128	45
7	168	174	133	75
8	179	198	80	52
9	136	152	145	39
10	192	186	91	60
M	157.00±6.85	174.00±6.20	91.00±8.29	57.00±4.20
S. D.	31.50±4.29	28.50±4.37	38.10±5.84	19.30±2.95
C. V.	20.00±3.15	16.30±2.54	41.80±7.42	33.80±5.70

any sign of flowering. The flowers did not develop properly because of the severe attack of thrips. The Red Brown Bombay, however, produced a few seeds which when sown gave two seedlings that grew to maturity (see Plate IV, fig. 2).

The test during the 1934–1935 regular onion season (December to April) showed in a striking way the effect of "wintering" the mother bulbs before planting. The effect was principally manifested on the percentage of plants that flowered, and on the number of days to flower. Table 8 presents the summary results of these observations, while Table 9 gives some data on the average number and height of leaves before flowering and the average number and height of the flower stalks per mother bulb as affected by the storage temperature before planting.

Table 10 presents some data on the percentage of flowering of different varieties of onion as affected by storage temperature while Table 11 gives the percentage of the flowering plants that produced seeds. The failure of many plants to set in seeds was primarily due to the attack of thrips. The same pest was the principal cause of the improper maturity of the seeds produced.

DISCUSSION OF RESULTS

The onion flower and its pollination.—So that there may be a better understanding of the dissertation, an examination of the onion flower and its pollination, although it is not the main

TABLE 4.—*Showing the relative number of seeds developing from one flower of different varieties of onion*

Value (Number)	Frequency					
	Red Globe		Red Brown Bombay		White Bombay	Yellow Bermuda
	B [a]	B_1 [a]	B	B_1	B	B
1	173	21	48	58	19	6
2	201	46	72	62	25	4
3	227	89	65	64	35	7
4	196	75	49	61	13	5
5	148	49	29	47	15	4
6	56	21	17	36	3	3
	1,001	301	280	328	110	29
M	3.11±0.03	3.49±0.05	2.97±0.06	3.25±0.06	2.99±0.09	3.21±0.20
S. D.	1.47±0.02	1.29±0.04	1.43±0.04	1.60±0.04	1.34±0.61	1.61±0.14
C. V.	47.20±0.85	36.90±1.13	48.10±1.64	49.20±1.56	44.80±2.41	50.10±5.24

[a] Bulbs stored in cold storage at about 10° C. from October 29, 1934, to January 8, 1935 (71 days).

B_1 [a] Bulbs of plants that flowered the previous season and stored in the same manner as B.

TABLE 5.—*Showing the per cent of seeding of individual onion flowers bagged before opening*

Variety names	Number of individual flowers:			Per cent seeding
	Bagged	That produced seeds	That failed to set in seeds	
Red Globe	18	0	18	0.00
Red Brown Bombay	62	2	60	3.22
White Bombay	52	0	52	0.00
Yellow Bermuda	21	1	20	4.76

TABLE 6.—*Showing the effect of monthly planting of onion bulbs on the flowering of two varieties of Bermuda onion at the Lipa Coffee-Citrus Station*[1]

Variety name and kind of bulb planted	Date		Number of bulbs planted	Per cent stand	Total yield				Remarks
	Planted	Harvested			Number of bulbs		Weight of bulbs		
					Per plant	Total	Per plant	Total	
							grams	*grams*	
1. Yellow Bermuda:									
Big bulb [a]	12–VI –33	10–VIII–33	100	94	2.66	250	43.0	4044	No sign of flowering.
Small bulb [b]	12–VI –33	10–VIII–33	100	81	1.75	142	31.3	2535	Do.
2. Red Bermuda:									
Big bulb	12–VI –33	10–VIII–33	100	77	2.04	157	33.6	2584	Do.
Small bulb	12–VI –33	10–VIII–33	100	79	1.61	127	23.5	1856	Do.
1. Yellow Bermuda:									
Big bulb	12–VII–33	23–IX –33	100	73	1.67	122	34.6	2524	No sign of flowering.
Small bulb	12–VII–33	23–IX –33	100	74	1.05	78	23.0	1701	Do.
2. Red Bermuda:									
Big bulb	12–VII–33	23–IX –33	100	87	2.57	224	60.1	5230	Do.
Small bulb	12–VII–33	23–IX –33	100	89	1.92	171	41.0	3650	Do.

[1] A monthly planting was made from June to October 1933. Due to poor stand of the crop in the August to October plantings data on yield were not taken although they were closely observed with respect to flowering. No plants were observed to have shown signs of flowering.

[a] Bulbs over 2.0 cm. in diameter were considered big.

[b] Bulbs 2.0 cm. in diameter or less were considered small.

TABLE 7.—*Showing the effect of storage temperature on the flowering of onion bulbs of different varieties*

Treatment of mother bulbs	Variety names	Date					Number of bulbs growing	Plants with flowers:		Remarks
		Planted	First flowering stalk emerged	First flower opened	Seed matured	Seed harvested		Number	Per cent	
(Control 1) Stored under ordinary room condition.	Yellow Bermuda	10–VIII–34					88	0	0	No sign of flowering.
	Red Brown Bombay	10–VIII–34					94	0	0	Do.
	White Bombay	10–VIII–34					84	0	0	Do.
	Saede	10–VIII–34					92	0	0	Do.
	Beheri	10–VIII–34					90	0	0	Do.
Stored for one month in cold storage at 10. °C.	Yellow Bermuda	6–VII–34					175	0	0	No sign of flowering.
	Red Brown Bombay	6–VII–34	30–VII –34	16–VIII–34	1–X–34	[a] 1–X–34	88	22	25.00	Flowers were badly attacked by thrips.
	White Bombay	6–VII–34	6–VIII–34	22–VIII–34	4–X–34	[b] 3–X–34	41	3	7.30	
	Red Globe	6–VII–34	1–VIII–34	16–VIII–34	—	—	86	4	4.60	
	Saede	6–VII–34	10–VIII–34	23–VIII–34	—	—	44	8	18.00	
Stored for two months in cold storage at 10. °C.	Yellow Bermuda	8–VIII–34					33	0	0	No sign of flowering.
	Red Brown Bombay	8–VIII–34	10–IX–34	17–IX–34			30	6	20.00	Flowers were badly attacked by thrips.
	White Bombay	8–VIII–34	12–IX–34	20–IX–34			29	4	13.70	
	Red Globe	8–VIII–34	8–IX–34	20–IX–34			27	2	7.40	
	Saede	8–VIII–34	30–IX–34				21	2	9.50	

[a] Four good seeds only were obtained; two germinated when sown which grew to maturity.
[b] Seeds harvested were all empty and undeveloped.

TABLE 8.—*Showing the effect of "wintering" mother bulbs on the number of days to germination, flowering and maturity of different varieties of onion*

Variety names	Number of days from:											
	Planting to germination		Planting to emergence of flowering stalks		Emergence of flowering stalks to rapture of bract		Rupture of bract to opening of first flower in a head		Rupture of bract to opening of last flower in a head		Planting to maturity[1]	
	A[2]	B[2]	A	B	A	B	A	B	A	B	A	B
Red Globe	3	3	33–63	17–51	10	10	10	11	18	18	----	86–92
Red Brown Bombay	3	4	41–65	19–55	9	11	9	9	21	20	----	86–92
White Bombay	4	3	48–59	17–63	10	11	(*)	11	(*)	24	----	86–92
Yellow Bermuda	5	3	(*)	27–43	(*)	19	(*)	5	(*)	14	----	86–92
Saede	6	5	(*)	28–39	(*)	18	(*)	7	(*)	19	----	86–92

[1] Because of the severe attack of thrips, the fruiting stalks dried off prematurely, hence the even number of days to maturity.
[2] A. Bulbs stored under ordinary room temperature.
B. Bulbs stored in cold storage at about 10° C. from October 29, 1934; to January 8, 1935 (71 days).
* The plants were observed not to have shown any sign of flowering.

TABLE 9.—*Showing some data on the total average height and number of leaves and height and number of flowering stalks per mother bulb of different varieties of onion as affected by storage temperature.*

Variety names	Treatment of bulbs before planting[1]	Average height of tallest leaf	Average number of leaves per plant before flowering	Average number of flowering stalks per bulb planted	Average height of flowering stalks
		cm.			*cm.*
Red Globe	A			1.05±0.03	49.30±3.50
	B	56.06±0.83	9.60±0.15	1.07±0.02	59.56±0.99
	B_1			1.16±0.07	62.60±1.13
Red Brown Bombay	A			1.00	44.86±0.66
	B	49.71±0.76	9.42±0.17	1.33±0.06	48.46±1.21
	B_1			1.23±0.07	51.96±1.53
White Bombay	A			1.00	40.20
	B	48.25±0.86	7.41±0.48	1.08±0.05	46.64±1.29
	B_1			1.16±0.10	50.87±1.51
Yellow Bermuda	A				
	B	49.18±1.28	8.10±0.41	1.00	41.95±1.22
Szede	A			1.00	
	B				

[1] A. Bulbs stored under ordinary room temperature.

B. Bulbs stored in cold storage at about 10° C. from October 29, 1934, to January 8, 1935 (71 days).

B_1. Bulbs of onion plants that flowered previously and stored in the same manner as B.

object of this study, is hereby presented in the first part of the discussion.

The onion flower is perfect; it contains the essential sex organs of a flower. The flowers are borne on an inflorescence (see Plate 1, figs. 1 and 2). As the mother bulb is planted, it produces leaves and often splits into two or more plants all capable of producing flower stalk. This flower stalk, as was observed in Manila and in Los Baños, began to show up from the surrounding leaf sheats in from 17 to 65 days after planting. It developed rapidly and so did its flower buds which were still enclosed in an onion-paper-like membrane. In 9 to 19 days after the flower stalk had appeared, the membrane enclosing the inflorescence was ruptured and in 5 to 11 days more, the first flower in an inflorescence opened. It was also observed that the last flower in an inflorescence opened in from 14 to 24 days after the rupture of the bract (see Table 8).

TABLE 10.—*Showing the effect of storage temperature on the percentage of flowering of different varieties of onion.*

Variety names	Treatment of bulbs before planting[1]	Number of bulbs growing	Bulbs flowering	
			Number	Per cent
Red Globe	A	81	38	46.91
	B	144	119	82.64
	B^1	17	16	94.12
Red Brown Bombay	A	65	17	26.15
	B	62	42	67.74
	B^1	25	23	92.00
	C	74	21	28.38
White Bombay	A	41	7	17.07
	B	29	21	72.41
	B^1	14	10	71.43
	C	53	2	3.77
Yellow Bermuda	A	29	0	0
	B	73	15	20.55
	C	23	0	0
Saede	A	55	0	0
	B	39	7	17.95
	B^1	7	2	28.57
	C	76	4	5.26
Beheri	A	10	0	0
	C	32	1	3.13

[1] A. Bulbs stored under ordinary room temperature.

B. Bulbs stored in cold storage at about 10° C. from October 29, 1934, to January 8, 1935 (71 days).

B_1. Bulbs of onion plants that flowered previously and stored in the same manner as B.

C. Bulbs stored in cold storage at about 10° C. from December 11, 1934, to January 8, 1935 (28 days).

Like corn, the onion flower has two sets of stamens, the inner and outer, and each set is composed of three stamens. The inner whorl of stamens was observed to develop and dehisce its pollen first, the discharge occurring in 4 to 9 hours after opening under Los Baños conditions. Before the first whorl of stamens has dehisced, however, the outer whorl simultaneously began to develop and this in turn, discharged its pollen 14 to 28 hours after the opening of the flower. The stamens in a flower became wilted in 29 to 59 hours after opening (see Table 2). In California, Jones and Emsweller (1933) found that it took "23 hours before all the anthers of any flower had dehisced, and

TABLE 11.—*Showing the percentage of mother bulbs that produced seeds*

Variety names	Treatment of bulbs before planting[1]	Number of bulbs which flowered	Bulbs that produced some seeds	
			Number	Per cent
Red Globe	A	38	0	0
	B	119	55	46.22
	B^1	16	8	50.00
Red Brown Bombay	A	10	0	0
	B	42	16	38.10
	B^1	23	9	39.13
	C	21	0	0
White Bombay	A	7	0	0
	B	21	11	52.38
	B^1	10	5	50.00
	C	2	0	0
Yellow Bermuda	A	0	0	0
	B	15	2	13.33
	C	0	0	0
Saede	A	0	0	0
	B	7	0	0
	B^1	2	0	0
	C	4	0	0
Beheri	A	0	0	0
	C	1	0	0

[1] A. Bulbs stored under ordinary room temperature.

B. Bulbs stored in cold storage at about 10° C. from October 29, 1934, to January 8, 1935 (71 days).

B_1. Bulbs of onion plants that flowered previously and stored in the same manner as B.

C. Bulbs stored in cold storage at about 10° C. from December 11, 1934, to January 8, 1935 (28 days).

about 47 hours before shedding of the pollen was completed." They further claim "that most of the pollen was shed between 9.30 a. m. and 5 p. m." Under Los Baños conditions, in an observation for a period of five days on the opening of the onion flower, about 28.38 per cent opened between 6 and 9 a. m.; about 27.11 per cent between 9 and 12 a. m.; 10.59 per cent from 12 to 3 p. m.; 6.35 per cent from 3 to 6 p. m.; and 27.19 per cent from 6 p. m. to 6 a m. (see Table 1).

The stigma was observed to have a slow growth; it attained its full length some time after the stamens had dehisced and wilted. But whether the stigma is receptive soon after the

flower had opened or when it had attained its full length has not been definitely ascertained. However, individual flowers that were bagged with oil paper envelops before opening were found to be practically incapable of producing seeds. As seen in Table 5, only two varieties of the five tested had some flowers setting in seeds, and this varied from 3.22 to 4.76 per cent. This fact together with the observation that the stigma did not attain its full length until some time after the wilting of the stamens seem to point out that the stamens and stigma of a flower do not mature at the same time. This observation is in consonance with a similar observation in California (1933). This is important from the breeding standpoint because the cumbersome work of opening the delicate flowers artificially in order to perform emasculation may be eliminated. Emasculation could be done after the flower has opened. However, the fact that the stamens and stigma do not mature at the same time does not preclude the onion from being selfed; the flowers in a head continue to open over a period of 19 to 24 days (see Table 8) as against over a period of two weeks in California as reported by Jones and Emsweller (1933). Bagging the onion head before any of its flowers opened in order to exclude insects did not prevent the setting of seeds. It was observed that the onion flowers were visited by various kinds of bees, and wasps but the more common were some species of the syrphid fly. These insects were no doubt agencies of pollination.

A study of the cross-section of the flower showed that it has three carpels and each carpel has two ovules (see Plate I, fig. 2, No. 2). It is obvious, therefore, that the maximum number of seeds a flower would produce is six. However, actual counts made with different varieties showed that the average number of seeds produced per flower was 3.11 ± 0.03 to 3.49 ± 0.05 for Red Globe; 2.97 ± 0.06 to 3.25 ± 0.06 for Red Brown Bombay; $2.99 \pm 2.99 \pm 0.09$ for White Bombay; and 3.21 ± 0.20 for Yellow Bermuda. The range was from 1 to 6 seeds per flower. The per cent of seeding was comparatively low, perhaps, because of the severe attack of thrips which naturally inhibited the normal development of the seeds. Jones and Emsweller (1933), however, claim that 50 per cent set is seldom obtained even under ideal conditions. They obtained the "heaviest yield of seeds under open-pollinated conditions; but even then there was only a 32 per cent set."

As seen in Table 11, the seeds that set in did not all develop into good seeds. Actual counts on four varieties showed that the average percentage of good seeds based on the number of seeds obtained per inflorescence (head) ranged from 69.80 to 82.84. When based on a perfect setting (6 seeds per flower), the range of setting varied from 48.48 to 56.19 per cent.

Monthly planting of onion bulb for seed production.—An attempt to find a suitable season of the year to plant onion bulb at the Lipa Coffee-Citrus Station, Lipa, Batangas, so that it would flower and produce seed was not productive of encouraging results. This was true with the two varieties of Bermuda onion tried—the Red Bermuda and the Yellow Bermuda. The test has not covered a year cycle, but the planting time has included practically the best season for regular onion bulb production. The trial test, however, has shown that onion sets can be raised for multiplication purposes (see Table 6).

"Wintered" vs. "nonwintered" mother bulb for seed production.—The trial test of "wintered" and "nonwintered" mother bulbs at the Central Experiment Station showed that "wintering" had a decided effect on the flowering of most of the varieties tested. As far as the writers have been able to ascertain, this study was the first successful attempt to make the big-bulbed onions flower under Philippine conditions. Of course, the senior author was able to produce some flower stalks of the variety Red Creole in 1932 at the Baguio Semi-Temperate Fruit Station, Baguio, Mounain Province, but these few flower stalks failed to produce any seeds. The flowering was, perhaps, due to the comparatively cool climate.

The effect of "wintering" the mother bulb planting on its ability to produce flower was very pronounced. Of the six varieties tested at the Central Experiment Station during the rainy season of 1934, not a single plant of the control plots (the mother bulbs were stored under ordinary room temperature) showed any sign of flowering. In the plots planted with "wintered" bulbs with the exception of that planted to Yellow Bermuda, the percentage of flowering varied from 4.6 to 25 per cent. The Yellow Bermuda did not show any sign of response (see Table 7).

In the regular onion season test (December to April 1934–1935) at the Los Baños Economic Garden, the effect of "wintering" the mother bulbs was more pronounced. Of the six

varieties tested, the "wintered" lots gave a percentage of flowering ranging from 3.13 to 94.12. It was apparent in the result obtained that the effect of "wintering" varied with the different varieties tested, and the length of time the bulbs were kept in cold storage. Red Globe, Red Brown Bombay, and White Bombay were the varieties that gave the best response to "wintering." Beheri, Yellow Bermuda, and Saede gave the poorest response. When stored in cold storage (10°C.) for a period of 71 days, Red Globe gave a percentage of flowering ranging from 82.64 to 94.12; Red Brown Bombay from 67.74 to 92; White Bombay from 71.43 to 72.41; Saede from 17.95 to 28.57; and Yellow Bermuda, 20.55. When the duration of the cold storage was only 28 days the response on flowering was markedly less. The percentage of flowering of Red Brown Bombay, White Bombay, Saede, Beheri, and Yellow Bermuda were 28.38, 3.77, 5.26, 3.13 and 0, respectively.

It was also shown in this experiment that the ability of the onion plant to flower under Philippine conditions without treatment was a varietal characteristic. Some of the plants in the control plots of Red Globe, Red Brown Bombay, and White Bombay flowered, the percentage of flowering being 46.91. 26.15, and 17.07, respectively. This part of the result is very significant; it points some possibility of isolating some strains that may have a high percentage of flowering even when the bulbs are not "wintered." The process of "wintering" would be a limiting factor in onion seed production in the Islands; artificial "wintering" being very costly. It would be hard for small farmers to produce their seeds through the "wintering" process. The value of evolving strains or varieties of onion that flower and seed freely without treatment is, therefore, quite obvious.

The effect of "wintering" was also manifested in the earliness to flower, and in the number and height of the flower stalks. While the number of days from planting to flowering differed in the different varieties, it was found in all cases that "wintered" bulbs flowered earlier than the bulbs stored under ordinary room conditions (see Table 3.) The "wintered" bulbs as seen in Table 4 had the tendency to produce more flowering stalks per mother bulb. Also these flowering stalks were taller than those from the control plots.

It will be seen in Table 7 that only three varieties of those that flowered actually produced some seeds. And those that

produced seeds came from "wintered" bulbs for a period of 71 days. This, however, does not mean that the other plants that flowered from other varieties and other treatments were incapable of seed production. The trouble was that those plants flowered later, and they were very much more badly attacked by thrips thus dying prematurely, causing their failure to set in seed. Based on the number of plants that flowered, White Bombay gave the highest percentage of seeding, followed by Red Globe, Red Brown Bombay, and Yellow Bermuda. The percentage of plants producing seeds was 50 to 52.38 for White Bombay, 46.22 to 50 for Red Globe, 38.10 to 39.13 for Red Brown Bombay, and 13.33 for Yellow Bermuda.

SUMMARY AND CONCLUSIONS

1. This paper presents the results of the first attempt to make the big-bulbed onions produce flowers and seeds under Philippine conditions. The data here presented represent the results of two years' work.

2. The onion flower is a perfect flower; it has six stamens, grouped into inner and outer whorls, each set elongating and dehiscing at different times. It has one ovary with three carpels and is capable of producing six seeds.

3. The onion flower under Los Baños conditions has been observed to open any time of the day but the majority opened between 6 and 12 o'clock in the morning. The first set of stamens was observed to dehisce its pollen in 4 to 9 hours after the opening of the flower while the last set dehisced in 14 to 28 hours after opening. The stamens in a flower became wilted in 29 to 59 hours after the opening of the flower.

4. The stamens and stigma in a flower did not mature at the same time. The style was observed to grow slowly; it attained its full length only some time after the stamens have dehisced their pollen. Individual flowers bagged before opening were practically incapable of setting in seeds. The onion, however, is not precluded from being self-pollinated because the flowers numbering over one hundred are grouped in an inflorescence, and these continue to open over a period of 19 to 24 days. The onion flowers were observed to have been visited by different kinds of insects.

5. The perfect set of seeds in onion is 6 seeds per flower. Under Los Baños conditions, the number of seeds produced per

flower of the five varieties studied varied from 2.97 ± 0.06 to 3.49 ± 0.05 seeds.

6. The ability of the onion plant to flower under Philippine conditions seemed to be a varietal characteristic. Untreated mother bulbs of Red Globe, Red Brown Bombay, and White Bombay gave 46.91, 26.15, and 17.07 per cent as their respective percentages of flowering. Four other varieties tested did not show any sign of flowering.

7. The flowering of the onion was accelerated by storing the mother bulb first in cold storage (10°C.) for a period of 28 to 71 days. Plants from "wintered" mother bulbs flowered earlier and had higher percentage of flowering than plants from non-wintered bulbs. The per cent of flowering of plants from "wintered" bulbs ranged from 82.64 to 94.12 for Red Globe; 67.74 to 92 for Red Brown Bombay; 71.43 to 72.41 for White Bombay; 17.95 to 28.57 for Saede; and 20.55 for Yellow Bermuda.

8. Of the six varieties that flowered only three (Red Globe, Red Brown Bombay, White Bombay) actually produced seeds to maturity. The failure of some of the varieties to produce seeds was mainly due to the severe attack of thrips. The seeds produced, when tested a couple of weeks after harvesting, were found viable. The seed of Red Brown Bombay that was first produced locally, when planted, grew to maturity (see Plate 4, fig. 2).

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2. Cates, J. Sidney. Plant-Riddle surprises. *Country Gentlemen.* Vol. CIII, December issue (1934).
3. Jones, R. A. and S. L. Emsweller. Methods of breeding onions. Cal. Agric. Expt. Station. Hilgardia 7 (1933), 625–642.

ILLUSTRATIONS

Plate 1

Fig. 1. The onion flower at different stages of development, *1*, a flower bud about to open. *2*, a flower beginning to open, with the inner whorl of stamens (*c*) coming out. *3*, an open flower with the inner whorl of stamens (*c*) about to shed its pollen, note the short style (*e*). *4*, a flower with its inner whorl of stamens having shed its pollen, and the outer whorl elongated and about to dehisce. *5*, a flower with all the stamens having shed their pollen, and the style fully developed, note its length.

2. An onion flower, dissected and drawn under a microscope showing its parts: *a*, bract, *b*, sepal, *c*, inner whorl of stamens; *d*, outer whorl of stamens, *e*, style; *f*, ovules; *g*, pistil. *1*, a longitudinal section showing the carpel and the ovules, note that each carpel has two ovules. *2*, a cross-section showing the arrangement of the parts of the flower. Note the three carpels with two ovules each. *3*, some pollen grains magnified.

Plate 2

Fig. 1. Some onion plants with the flower stalks just emerging. Note the young flower stalks capped white.

2. An onion plant with its flower stalk fully developed, and its wrap already ruptured.

3. An onion plant with its flowers already opened.

Plate 3

Fig. 1. A plot of (*a*) "wintered" bulbs, and (*b*) "non-wintered" bulbs. Note that the plants in (*a*) are in full bloom; and those in (*b*) are just beginning to flower.

2. Typical flower stalks of different varieties of onion. Note their relative length, and the size of the inflorescence.

Plate 4

Fig. 1. An onion bulb—the product of a mother bulb that was planted for seed purposes. Each of the bulbs under favorable conditions is capable of producing a flower stalk.

2. Red Brown Bombay onion—the bulbs of the first seeds produced in the Philippines due to "wintering" of the mother bulb before planting. The comparatively small size was mainly due to improper maturity because of the severe attack of thrips.

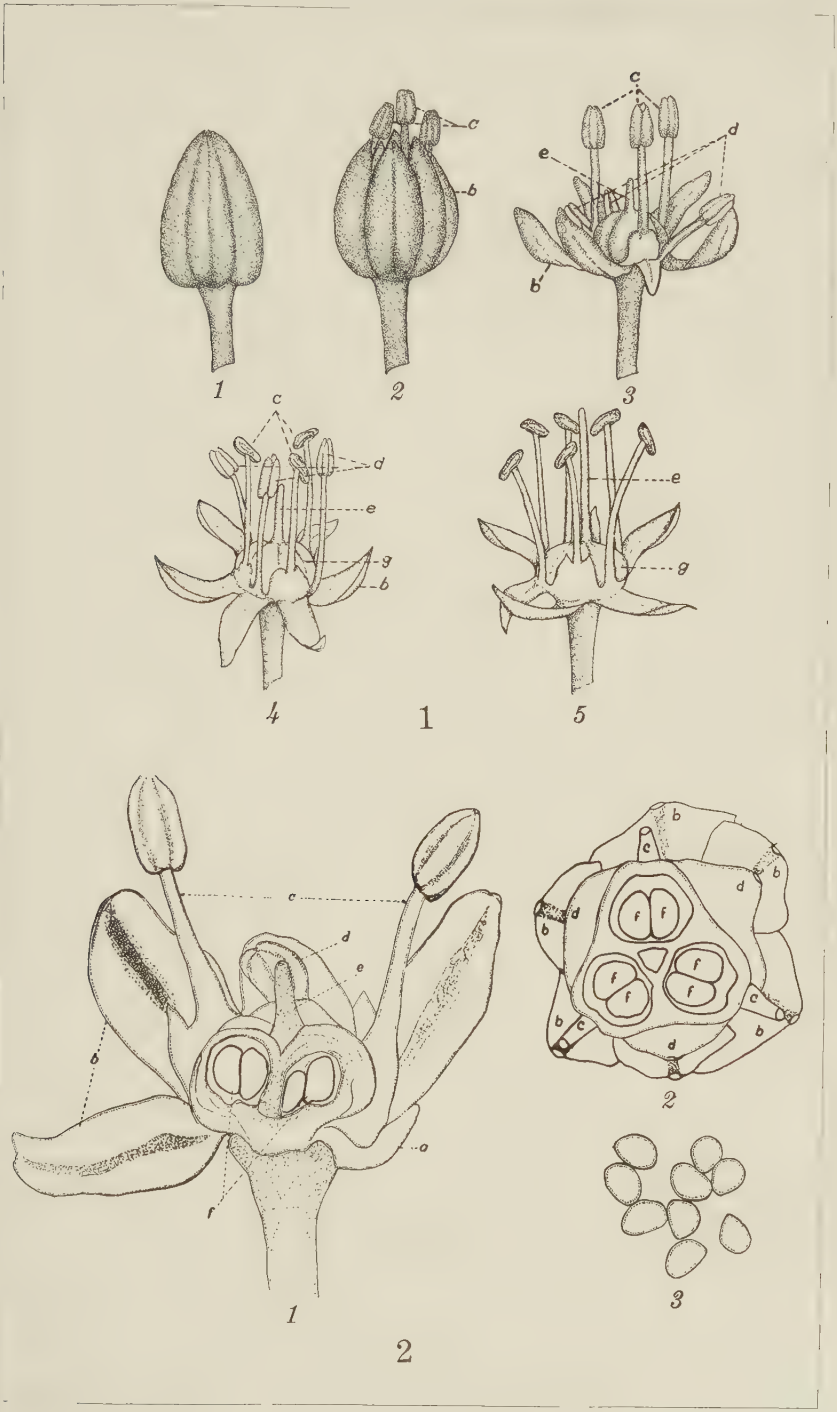

PLATE 1.

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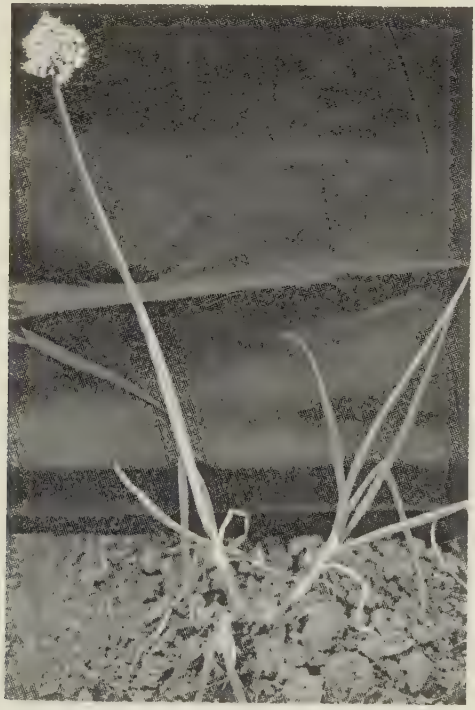

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PLATE 2.

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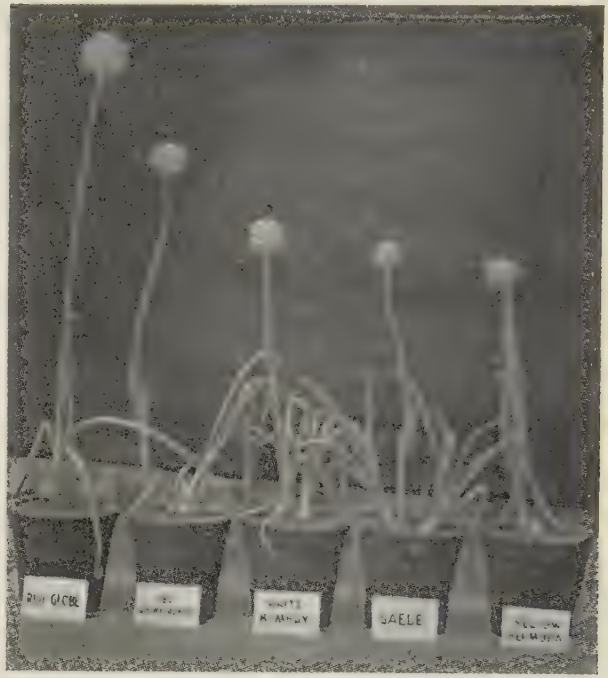

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PLATE 3.

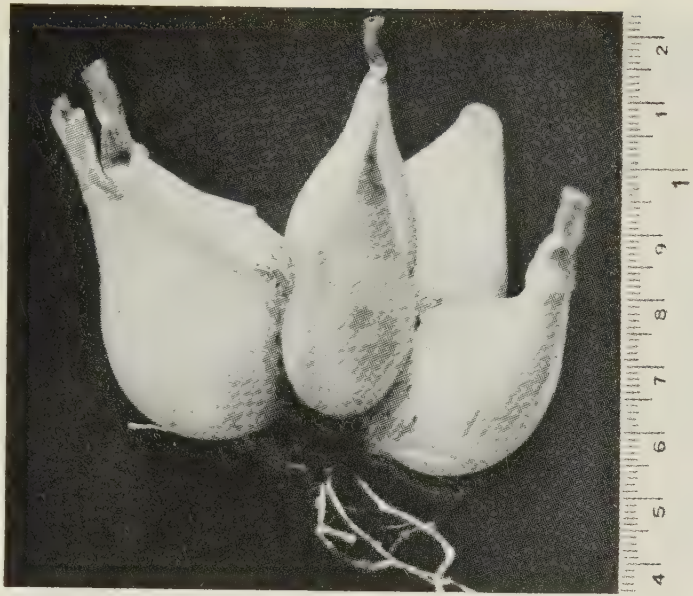

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PLATE 4.

FRUITING AS RELATED TO VEGETATIVE GROWTH IN CASHEW, *ANACARDIUM OCCIDENTALE* L.

By FRANCISCO G. GALANG and FELIX D. LAZO
Of the Horticulture Section, Bureau of Plant Industry

THREE TEXT FIGURES

The cashew, *Anacardium occidentale* L., is cultivated for its kidney-shaped seed, commercially known as *cashew nut,* and for its swollen peduncle and disk, termed *cashew apple.* The kernel has a delicious as well as delicate flavor. Like the peanut, it makes a good candy or chocolate, either alone or mixed with cacao. It produces a valuable oil having similar properties to chaulmoogra oil and is comparable with almond oil. Cashew oil can be used for painting. The fruit is eaten off hand and makes good wine, vinegar, jam or preserve. It is also used as feed for hogs. It is sometimes prescribed as a remedy for dysentery because of its tannin content. Its juice, which is about 65 per cent of the weight of the fruit, when mixed with iron sulphate, makes an excellent hair dye.

The growing of cashew for export to the United States and Europe has a tremendous possibility. Yet, little attention, if at all, is given to it. Even literature on the subject is scarce, indeed. In the present study the aim is to find the relationship between vegetative growths and the fruiting ability of the cashew and then by means of appropriate cultural practices induce such growths as are associated with fruiting.

The work of previous researchers have been availed of to throw light on this subject, thus: Roberts (7) reported that an increase in diameter of the wood of an apple tree is favorable to blossom formation, and that fruitfulness is related to wood growth. The same author found out also that when the spurs were longer there were more leaves and so the leaf-area was naturally greater. He further observed that there was more growth in the regular bearing apple tree than in the biennial bearing individual. Similar result was obtained on tomato plant by Kraus and Kraybill (4). Growth in diameter as an index of flower bud formation was suggested by Crow and Edit (1).

Also, Galang and Lazo (2) reported that in fruiting Carabao mango trees, the average length and diameter of the bearing twigs were greater than those of the nonbearing twigs of both bearing and nonbearing unthrifty trees but less than those of nonbearing robust trees. Gourley (3) suggested that large leaf surface is associated with fruit bud formation. Magness (5) said that in most varieties of apples, in the absence of a fair amount of leaf-area, fruit bud initiation will not take place and fruit bud will not be formed. Magness, et al. (6) said that there is a correlation between the number of leaves and the development of the fruits, although the increase in size of the fruit is not in proportion to the increase in foliage.

MATERIALS AND METHODS

The materials used in this study were the cashew trees of the Lamao Horticultural Station, Limay, Bataan, and a few others in the neighborhood. They were of varying ages, from about 10 to around 30 years old. All of the trees studied were grown from seeds. In spite of the very little care given, the cashew trees were growing vigorously, and the place may now be considered a suitable district for cashew growing. Observations were made during the fruiting seasons from 1933 to 1935. Throughout the study all the cashew trees of bearing age flowered. In this respect the cashew tree differs from the mango in that the former is a regular bearer, while the latter is not.

It may be mentioned in passing that the cashew flower is not born immediately by the bearing twig as in the case of the mango, but an intermediary flush is produced which for convenience may be termed *flower-flush.* At the terminal of this flower flush the flower panicle (see fig. 1) grows. When the flower panicle and fruits fade and die vigorous lateral twigs develop. This habit of growth explains in part why the branches of the cashew are not straight.

The characters studied in this work were the length and diameter of the twigs, number and area of the leaves in both the bearing and nonbearing twigs of cashew trees. Also, the length and diameter of the flower-flush, the number and area of leaves of both the bearing and nonbearing flower-flushes were taken in order to determine what growth characters are associated with bearing. Bearing twigs as used in this study refer to those which produced flower-flushes that developed flower panicles.

All twigs behaving otherwise were considered and recorded nonbearing. Both terminal and lateral twigs or shoots in the four cardinal directions—north, south, east, and west—were studied in order to counteract the possible effect, if any, of the sunshine and wind velocity on the development of the twigs.

The length of each twig was taken by measuring from its terminal point—the place where the July or midseason growth ended to the origin of the preceding flower flush. The length of the bearing flower flush was measured from the base to the axil of its last leaf at the tip. In the case of the nonbearing flower flush the apical end was the other base. In both cases, the diameter was obtained midway between the two base marks (see figs. 1 and 2). The leaves produced between the base marks used in obtaining the length of each shoot and flower flush were counted and some measured both in length and width. The length of leaves was taken from the tip to the leaf base, that is, excluding the petioles. The width was obtained from the broadest part (see fig. 3).

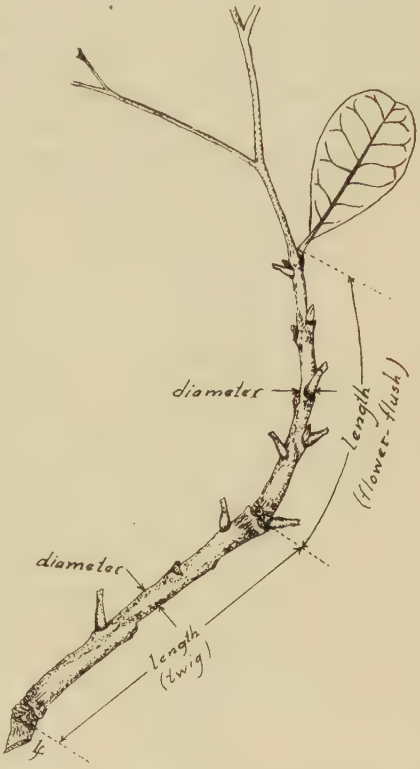

FIG. 1. A cashew bearing twig with flower-flush and basal of flower panicle.

EXPERIMENT AND RESULTS

The cashew trees used in this study were grown from seedlings. They were not, therefore, expected to behave or grow uniformly in the same way as individuals vegetatively raised from a pure strain. Nevertheless, the results obtained were consistently significant so that the findings in this study may be said to hold good for cashew in general instead of for a particular cashew strain.

It appears that the cashew tree has more than one season of active growth during the year. The first flushes were produced in March or after the fruiting season was over. The second flushes appeared in July when the rainy season was well in advance. Only a few—about five per cent—of the twigs have sent new growths this time. The third or the last growth for the year was in November, and at this time the greatest portion of the twigs produced new shoots. The flower panicles appeared after a short period of dormancy of the third shoots or during the early part of December.

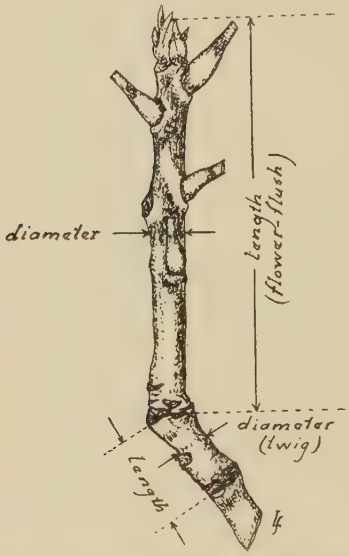

FIG. 2. A cashew nonbearing twig with flower-flush. The leaves were cut off to show the bases of measurements.

A total of 6,336 terminal and lateral bearing twigs with their corresponding flower flushes were measured. Likewise 6,334 nonbearing terminal and lateral twigs with their respective flower flushes were also studied. The bearing twigs had 22,356 total number of leaves, while the nonbearing produced only 16,086 leaves. For the average area of each leaf, 1,464 and 1,697 leaves were measured for the bearing and the nonbearing twigs, respectively.

The bearing flower flushes had a total of 39,540 and the nonbearing 23,678 leaves. Out of these figures, 2,364 leaves were measured from the bearing and 1,684 from the nonbearing flower flushes. The foregoing data were obtained from 32 cashew trees of varying ages.

Table 1 shows the difference between the bearing and the nonbearing twigs of cashew trees as a whole. Table 2 gives the difference between the bearing and the nonbearing flower flushes. Table 3 indicates the difference by direction between the bearing and the nonbearing twigs. Table 4 presents the difference by direction between the bearing and the nonbearing flower flushes.

DISCUSSION OF RESULTS

As may be seen in Table 1, both the terminal and the lateral bearing twigs of a cashew tree as a whole were longer and more

stocky. The terminal bearing twigs gave an average length and diameter of 3.56 ± 0.0260 cm. and 6.30 ± 0.0153 mm., respectively, against 2.66 ± 0.0190 cm. and 5.40 ± 0.0120 mm. for the nonbearing twigs. There were on the average 3.96 ± 0.0199 leaves of the terminal bearing twigs as compared with 2.93 ± 0.0241 leaves of the nonbearing ones. The mean area for each leaf of the terminal bearing twigs was 77.12 ± 0.8101 sq. cm., while that for the nonbearing twigs was 58.41 ± 0.6352 sq. cm. It was evident, therefore, that the terminal bearing twigs had greater total leaf area than the nonbearing ones.

In the case of the lateral twigs the results closely resembled those obtained with the terminal twigs; that is, the lateral bearing twigs were longer, greater in diameter and they had slightly more and bigger leaves than those of the lateral nonbearing twigs. All of these differences were significant as presented in Table 1. Also, it can be noted that except in leaf area where the leaves of the terminal nonbearing twigs were somewhat more variable, the lateral twigs, bearing or nonbearing, had higher coefficients of variability in length and diameter of twigs as well as in the number and average of the leaves.

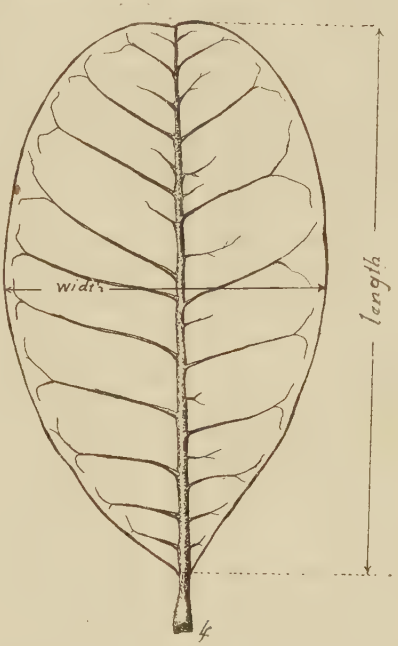

FIG. 3. A cashew leaf.

The terminal bearing flower flushes gave an average length and diameter of 6.27 ± 0.0391 and 5.84 ± 0.0126 mm., respectively, which were 4.05 ± 0.0420 cm. and 0.88 ± 0.0191 mm. greater than their corresponding parts in the nonbearing flower flushes (see Table 2). The leaves of the terminal bearing flower flushes were 2.44 ± 0.0380 more and 7.16 ± 0.8838 sq. cm. smaller in leaf area than the nonbearing ones. Nevertheless, the total leaf area for the nonbearing flower flushes was less because the bearing ones had more number of leaves.

The bearing flower flushes of the lateral twigs were 3.57 ± 0.0410 cm. longer, 0.90 ± 0.0167 mm. bigger in diameter, and

with 2.57 ± 0.0374 more leaves than those of the nonbearing flower flushes. But the leaves of the former were 10.46 ± 0.8727 sq. cm. less in the average area than the latter. However, as in the terminals, the total leaf area of the nonbearing flower flushes was less. This is due to the fact that the bearing flower flushes had more leaves than the nonbearing ones.

Table 3 indicates that in both the terminal and lateral twigs in the different cardinal directions the bearing twigs were longer and more stocky. They also had more and bigger sized leaves. These conditions were significantly obtained in all the four quadrants—east, west, north, and south—except in the length of the eastern lateral and the western terminal twigs where the difference was insignificant. This simply demonstrated that sunshine and wind velocity had negligible effects, if at all, on the characters under consideration. As may be seen in Table 1, considering the results as a whole, all the characters studied were pronouncedly in favor of the bearing twigs in growth.

Even the flower flushes in the different directions were longer, bigger and with more but smaller leaves in a great majority of cases as may be seen in Table 4. There had been an isolated case where the diameter of nonbearing flower flushes (in the eastern terminal) was greater, but when the data were subjected to the probable error concept the difference was insignificant. Like the results obtained when the data as a whole was considered (see Table 2), the average total leaf area of the bearing flower flushes was greater than that of the nonbearing flower flushes.

The results obtained were important and far-reaching. They gave hints as to what step should be taken to increase the production, if not to attain the maximum yield of cashew trees. This study definitely showed that in either the twigs or flower flushes, the bearing ones were longer, bigger and had greater total leaf area, regardless of their position and direction in the tree. The question of how can the vigor and thriftiness of the bearing twigs and flower flushes be forced in the tree is then in order. The problem of cashew is apparently simpler than that of the mango because in cashew there had not been observed any vigorous tree which did not produce flowers during the season, whereas in mango, it was rather common to find quite vigorous and thrifty trees which did not bear fruit or flower during its season. So, the danger of over vegetative

TABLE 1.—*Showing the difference between the bearing and nonbearing twigs of cashew trees*

Parts	Bearing twigs			Nonbearing twigs			Difference	Significance (5 x P. E. D.)
	Mean	Standard deviation	Coefficient of variability	Mean	Standard deviation	Coefficient of variability		
Terminal twigs:								
Length in cm.	3.56±0.0260	2.17±0.0184	60.95±0.6817	2.66±0.0190	1.59±0.0134	59.59±0.6566	0.90±0.0312	Significant.
Diameter in mm.	6.30±0.0153	1.28±0.0108	20.32±0.1791	5.40±0.0120	1.00±0.0085	18.52±0.1617	0.90±0.0194	Do.
Number of leaves	3.96±0.0199	1.66±0.0141	41.92±0.0412	2.93±0.0241	2.01±0.0170	68.60±0.8083	1.03±0.0312	Do.
Area of leaf in sq. cm.	77.12±0.8101	32.80±0.5727	42.53±0.8615	58.41±0.6352	27.62±0.4492	47.29±0.9231	18.71±1.0294	Do.
Lateral twigs:								
Length in cm.	4.46±0.0443	3.70±0.0314	82.96±1.0826	3.21±0.0316	2.64±0.0224	82.24±1.0662	1.25±0.0544	Significant.
Diameter in mm.	5.75±0.0155	1.29±0.0109	22.43±0.1977	4.87±0.0116	0.97±0.0082	19.92±0.1739	0.88±0.0193	Do.
Number of leaves	3.20±0.0278	2.32±0.0197	72.50±0.6450	2.21±0.0205	1.71±0.0144	77.38±0.9704	0.99±0.0343	Do.
Area of leaf in sq. cm.	64.17±0.7027	27.92±0.4970	43.31±0.9023	50.92±0.5125	21.98±0.3624	43.17±0.8328	13.25±0.8697	Do.

TABLE 2.—*Showing the difference between the bearing and nonbearing flower-flushes of cashew trees*

Parts	Bearing flower-flushes			Nonbearing flower-flushes			Difference	Significance (5 x P. E. D.)
	Mean	Standard deviation	Coefficient of variability	Mean	Standard deviation	Coefficient of variability		
Terminal flower-flush:								
Length in cm.	6.27±0.0391	3.26±0.0276	51.99±0.5463	2.22±0.0155	1.29±0.0109	58.11±0.6355	4.05±0.0420	Significant.
Diameter in mm.	5.84±0.0126	1.05±0.0089	17.98±0.1570	4.96±0.0114	0.95±0.0081	19.15±0.1672	0.88±0.0191	Do.
Number of leaves	6.35±0.0314	2.62±0.0222	41.26±0.4021	3.91±0.0215	1.79±0.0152	45.78±0.4618	2.44±0.0380	Do.
Area of leaf in sq. cm.	58.81±0.5350	27.57±0.3862	46.88±0.7815	65.97±0.7035	30.28±0.5098	45.90±0.9197	7.16±0.8838	Do.
Lateral flower-flush:								
Length in cm.	6.03±0.0375	3.13±0.0265	51.91±0.5454	2.46±0.0195	1.63±0.0138	66.26±0.7692	3.57±0.0410	Significant.
Diameter in mm.	4.80±0.0129	1.08±0.0092	22.50±0.1983	4.63±0.0107	0.89±0.0075	19.22±0.1677	0.90±0.0167	Do.
Number of leaves	6.13±0.0306	2.55±0.0216	41.60±0.4089	3.56±0.0216	1.80±0.0153	50.56±0.5226	2.57±0.0374	Do.
Area of leaf in sq. cm.	53.94±0.4975	25.08±0.3593	46.50±0.7927	64.40±0.7171	30.83±0.5197	47.87±0.9685	10.46±0.8727	Do.

TABLE 3.—*Showing the difference by direction between the bearing and nonbearing twigs of cashew trees*

Parts	Bearing twigs			Nonbearing twigs			Difference	Significance (5 x P. E. D.)
	Mean	Standard deviation	Coefficient of variability	Mean	Standard deviation	Coefficient of variability		
Eastern terminal twigs:								
Length in cm.	3.65±0.0550	2.26±0.0389	61.92±1.4165	2.76±0.0412	1.69±0.0298	61.23±1.4282	0.89±0.0687	Significant.
Diameter in mm.	6.26±0.0368	1.51±0.0260	24.12±0.4384	5.23±0.0248	1.02±0.0180	19.50±0.3548	1.03±0.0443	Do.
Number of leaves	3.99±0.0604	2.48±0.0427	62.16±1.4237	3.08±0.0516	2.12±0.0375	68.83±1.7030	0.91±0.0794	Do.
Area of leaf in sq. cm.	81.43±1.7577	35.91±1.2802	44.05±1.8498	64.12±1.3072	28.74±0.9240	44.82±1.7046	17.41±2.1904	Do.
Eastern lateral twigs:								
Length in cm.	5.27±1.0248	4.21±0.0724	79.89±2.0733	3.26±0.0613	2.52±0.0445	77.30±2.0206	2.01±1.0266	Insignificant.
Diameter in mm.	5.81±0.0239	0.98±0.0169	16.87±0.2985	4.72±0.0239	0.98±0.0173	20.77±0.3815	1.09±0.0337	Significant.
Number of leaves	3.37±0.0586	2.41±0.0415	71.51±1.7501	2.13±0.0426	1.75±0.0309	80.16±2.1379	1.24±0.0724	Do.
Area of leaf in sq. cm.	67.39±1.2965	24.47±0.9169	36.31±1.5293	52.41±1.0898	23.25±0.7706	44.36±1.7349	14.98±1.6936	Do.
Northern terminal twigs:								
Length in cm.	3.64±0.0537	2.25±0.0379	61.81±1.3841	2.70±0.0363	1.52±0.0256	56.30±1.2065	0.94±0.0648	Significant.
Diameter in mm.	6.56±0.0296	1.24±0.0210	18.90±0.0329	5.41±0.0239	1.00±0.0169	18.49±0.3213	1.15±0.0380	Do.
Number of leaves	4.24±0.0587	2.46±0.0415	58.02±1.2512	2.93±0.0475	1.99±0.0336	67.92±1.5816	1.31±0.0755	Do.
Area of leaf in sq. cm.	71.78±1.4022	29.25±0.9663	40.75±1.5941	59.25±1.1636	25.29±0.8225	42.68±1.6213	12.53±1.8221	Do.
Northern lateral twigs:								
Length in cm.	4.47±0.0785	3.29±0.0555	73.60±1.8243	3.23±0.0627	2.63±0.0443	81.42±2.0869	1.24±0.1004	Significant.
Diameter in mm.	6.04±0.0298	1.25±0.0211	20.70±0.3633	4.65±0.0240	0.99±0.0167	21.29±0.3734	1.39±0.0382	Do.
Number of leaves	3.23±0.0577	2.42±0.0409	74.92±1.8393	2.23±0.0429	1.80±0.0304	80.72±2.0555	1.00±0.0719	Do.
Area of leaf in sq. cm.	66.56±1.4036	27.76±0.9923	41.70±1.7292	53.53±1.0427	23.39±0.7372	43.69±1.6181	13.03±1.7485	Do.
Western terminal twigs:								
Length in cm.	3.45±0.6630	2.78±0.4688	80.58±2.0599	3.06±0.0398	1.67±0.0282	54.58±1.1596	0.39±0.6642	Insignificant.
Diameter in mm.	6.21±0.0267	1.12±0.0188	18.05±0.3140	5.08±0.0229	0.96±0.0169	18.90±0.3283	1.13±0.0351	Significant.
Number of leaves	5.15±0.0553	2.32±0.0391	45.05±0.9003	2.91±0.0496	2.08±0.0357	71.48±1.7115	2.24±0.0742	Do.
Area of leaf in sq. cm.	86.26±1.5466	30.68±1.0937	35.57±1.4189	53.96±1.1740	25.22±0.8302	46.74±1.8434	32.30±1.9417	Do.
Western lateral twigs:								
Length in cm.	4.38±0.0887	3.72±0.0627	84.93±2.2343	3.10±0.0580	2.43±0.0410	78.39±1.9694	1.28±0.1059	Significant.
Diameter in mm.	5.64±0.0281	1.18±0.0199	20.92±0.3676	4.54±0.0222	0.93±0.0157	20.48±0.3591	1.10±0.0358	Do.
Number of leaves	3.18±0.0515	2.16±0.0364	67.92±1.5873	2.28±0.0417	1.75±0.0295	76.75±1.9025	0.90±0.0662	Do.
Area of leaf in sq. cm.	64.82±1.3530	27.36±0.9567	42.21±1.7179	53.10±1.2972	26.29±0.9169	49.51±2.1063	11.72±1.8743	Do.

Southern terminal twigs:							
Length in cm.	3.37 ±0.0465	1.95 ±0.0329	57.86 ±1.2607	2.61 ±0.0329	1.38 ±0.0233	52.87 ±0.9896	0.76 ±0.0569	Significant.
Diameter in mm.	6.18 ±0.0296	1.24 ±0.0210	20.06 ±0.3514	5.08 ±0.0241	1.01 ±0.0170	19.88 ±0.3453	1.10 ±0.0381	Do.
Number of leaves	3.59 ±0.0563	2.36 ±0.0398	61.74 ±1.0553	2.82 ±0.0448	1.88 ±0.0317	66.67 ±1.5402	0.77 ±0.0719	Do.
Area of leaf in sq. cm.	70.73 ±1.5144	30.94 ±1.0708	43.75 ±1.7791	56.51 ±1.3708	29.59 ±0.9693	52.36 ±2.1340	14.22 ±2.0400	Do.
Southern lateral twigs:								
Length in cm.	4.15 ±0.0272	1.14 ±0.0192	27.47 ±0.4971	3.35 ±0.0673	2.82 ±0.0476	84.18 ±2.2002	0.80 ±0.0725	Significant.
Diameter in mm.	5.70 ±0.0286	1.20 ±0.0202	21.05 ±0.3703	4.54 ±0.0227	0.95 ±0.0160	20.93 ±0.3671	1.16 ±0.0365	Do.
Number of leaves	3.03 ±0.0529	2.22 ±0.0374	73.27 ±1.7791	2.10 ±0.0439	1.84 ±0.0310	87.62 ±2.3492	0.93 ±0.0687	Do.
Area of leaf in sq. cm.	61.29 ±1.4609	30.02 ±1.0331	48.98 ±2.0498	45.22 ±1.0310	22.47 ±0.7294	49.69 ±1.9712	16.07 ±1.7880	Do.

TABLE 4.—*Showing the difference by direction between the bearing and nonbearing flower-flushes of cashew trees*

Parts	Bearing flower-flushes			Nonbearing flower-flushes			Difference	Significance (5 x P. E. D.)
	Mean	Standard deviation	Coefficient of variability	Mean	Standard deviation	Coefficient of variability		
Eastern terminal flower-flush:								
Length in cm.	6.63 ±0.0852	3.50 ±0.0602	52.79 ±1.1331	2.35 ±0.0280	1.15 ±0.0203	48.94 ±1.0464	4.28 ±0.0896	Significant
Diameter in mm.	4.65 ±0.0258	1.06 ±0.0183	22.80 ±0.4123	4.78 ±0.0236	0.97 ±0.0171	20.29 ±0.3730	0.13 ±0.0349	Insignificant.
Number of leaves	6.24 ±0.0621	2.55 ±0.0439	40.87 ±0.8119	3.96 ±0.0458	1.68 ±0.0332	47.47 ±1.0067	2.28 ±0.0771	Significant.
Area of leaf in sq. cm.	60.37 ±1.2387	31.55 ±0.8761	52.11 ±1.7973	65.20 ±1.2209	26.41 ±0.8631	40.51 ±1.5248	4.83 ±1.7392	Insignificant.
Eastern lateral flower-flush:								
Length in cm.	6.48 ±0.0791	3.25 ±0.0559	50.15 ±1.0575	2.56 ±0.0385	1.58 ±0.0279	61.72 ±1.4389	3.92 ±0.0879	Significant.
Diameter in mm.	5.28 ±0.0248	1.02 ±0.0176	19.32 ±0.4392	3.45 ±0.0209	0.86 ±0.0152	24.93 ±0.4669	1.83 ±0.0324	Do.
Number of leaves	6.35 ±0.0643	2.64 ±0.0454	41.57 ±0.8200	3.52 ±0.0460	1.89 ±0.0334	53.69 ±1.1849	2.83 ±0.0790	Do.
Area of leaf in sq. cm.	54.10 ±1.0340	25.74 ±0.7310	47.58 ±1.6281	62.60 ±0.8040	17.32 ±0.5688	27.67 ±0.9748	8.50 ±1.3097	Do.
Northern terminal flower-flush:								
Length in cm.	5.87 ±0.0751	3.15 ±0.0531	53.66 ±1.1355	2.37 ±0.0370	1.55 ±0.0262	65.40 ±1.5009	3.50 ±0.0837	Significant.
Diameter in mm.	5.90 ±0.0167	0.70 ±0.0118	11.87 ±0.2029	4.70 ±0.0227	0.95 ±0.0160	20.21 ±0.3546	1.20 ±0.0281	Do.
Number of leaves	6.31 ±0.0632	2.65 ±0.0447	41.99 ±0.7923	3.82 ±0.0422	1.77 ±0.0299	46.34 ±0.9307	2.49 ±0.0759	Do.
Area of leaf in sq. cm.	56.97 ±1.0014	25.24 ±0.7082	44.30 ±1.4667	68.20 ±1.3485	30.05 ±0.9534	44.06 ±1.6468	11.23 ±1.6796	Do.
Northern lateral flower-flush:								
Length in cm.	5.79 ±0.0754	3.16 ±0.0533	54.58 ±1.1623	2.46 ±0.0394	1.65 ±0.0278	67.07 ±1.5494	3.33 ±0.0850	Significant.
Diameter in mm.	5.52 ±0.0250	1.05 ±0.1770	19.02 ±0.4208	4.42 ±0.0219	0.92 ±0.0156	20.81 ±0.3650	1.10 ±0.0332	Do.
Number of leaves	6.17 ±0.0594	2.49 ±0.0420	40.36 ±0.7833	3.63 ±0.0422	1.77 ±0.0298	48.76 ±0.9949	2.54 ±0.0728	Do.
Area of leaf in sq. cm.	53.92 ±0.9697	24.77 ±0.6856	45.94 ±1.5158	67.74 ±1.4845	32.11 ±1.0493	47.40 ±1.8634	13.82 ±1.7731	Do.
Western terminal flower-flush:								
Length in cm.	6.27 ±0.0706	2.96 ±0.0499	47.21 ±0.9568	2.16 ±0.0317	1.33 ±0.0224	61.57 ±1.3705	4.11 ±0.0773	Significant.
Diameter in mm.	5.54 ±0.0239	1.00 ±0.0169	18.05 ±0.3140	4.17 ±0.0191	0.80 ±0.0135	19.18 ±0.3332	1.37 ±0.0305	Do.
Number of leaves	6.60 ±0.0587	2.46 ±0.0415	37.27 ±0.7102	3.86 ±0.0410	1.72 ±0.0290	44.56 ±0.8868	2.74 ±0.0716	Do.
Area of leaf in sq. cm.	63.90 ±0.9089	23.96 ±0.6428	37.50 ±1.1376	66.14 ±1.3746	28.96 ±0.9718	43.78 ±1.7283	2.24 ±1.6479	Insignificant.

Western lateral flower-flush:								
Length in cm.	6.04±0.0745	3.12±0.0527	51.76±1.0813	2.37±0.0374	1.57±0.0265	66.24±1.5303	3.67±0.0833	Significant.
Diameter in mm.	5.15±0.2504	1.05±0.1770	20.39±0.3575	4.33±0.0212	0.89±0.0150	20.55±0.3604	0.82±0.2512	Doubtful.
Number of leaves	6.11±0.0608	2.55±0.0430	41.73±0.8170	4.03±0.0322	1.35±0.0228	33.50±0.6215	2.08±0.0689	Significant.
Area of leaf in sq. cm.	53.91±0.9501	23.44±0.6716	43.48±1.4615	65.69±1.5759	33.20±1.1141	50.54±2.0844	11.78±1.8401	Do.
Southern terminal flower-flush:								
Length in cm.	6.22±0.0749	3.14±0.0529	20.00±0.3373	2.41±0.0301	1.26±0.0212	52.28±1.0931	3.81±0.0807	Significant.
Diameter in mm.	5.57±0.0258	1.08±0.0182	19.39±0.3388	4.69±0.0241	1.01±0.0170	21.53±0.3775	0.88±0.0353	Do.
Number of leaves	6.31±0.0630	2.64±0.0445	41.84±0.8191	2.98±0.0427	1.79±0.0302	60.07±1.3270	3.33±0.0761	Do.
Area of leaf in sq. cm.	57.12±1.0119	26.33±0.7155	46.10±1.4944	64.04±1.5360	32.36±1.0859	50.53±2.0838	6.92±1.8393	Doubtful.
Southern lateral flower-flush:								
Length in cm.	5.79±0.0685	2.87±0.0484	49.57±0.2682	2.44±0.0298	1.25±0.0211	51.23±1.0624	3.35±0.0747	Significant.
Diameter in mm.	5.25±0.0258	1.08±0.0182	20.57±0.3610	4.35±0.0224	1.94±0.0159	21.66±0.3799	0.90±0.0341	Do.
Number of leaves	5.99±0.0651	2.73±0.0460	45.60±0.9143	3.55±0.0432	1.81±0.0305	50.99±1.0575	2.64±0.0781	Do.
Area of leaf in sq. cm.	52.60±0.9595	24.51±0.6371	46.59±1.1970	60.74±1.3412	29.15±0.9480	48.00±1.8860	8.14±1.6490	Doubtful.

growth at the sacrifice of fruit production in cashew may be said to be obviously less than in mango. It was reported by Galang and Lazo(2) that over vegetative growth in Carabao mango as in the case of nonbearing robust trees, impaired production.

SUMMARY OF CONCLUSIONS

1. The data presented were gathered during the last three fruiting seasons of cashew trees, and they showed sufficiently that like other fruit trees, as apple and mango, fruiting in cashew was associated with certain vegetative growth habits.

2. Considering the results as a whole, the terminal bearing twigs were on the average, longer and more stocky by 0.90 ± 0.0312 cm. and 0.90 ± 0.0194 mm., respectively, than the nonbearing twigs. The lateral bearing twigs were 1.25 ± 0.0544 cm. longer and 0.88 ± 0.0193 mm. greater in diameter than the nonbearing ones.

3. With respect to leaves the terminal bearing twigs had 1.03 ± 0.0312 more and 18.71 ± 1.0294 sq. cm. bigger and the lateral bearing twigs had 0.99 ± 0.0343 more and 13.25 ± 0.8697 sq. cm. greater in area than their counterparts in the nonbearing twigs.

4. Even in the case of the flower flushes, the bearing ones, either terminal or lateral, were also longer and greater in diameter. In the terminals there was a difference of 4.05 ± 0.0420 cm. in length and 0.88 ± 0.0191 mm. in diameter, while in the lateral the difference was 3.57 ± 0.0410 cm. and 0.90 ± 0.0167 mm. for length and diameter, respectively.

5. The terminal bearing flower flushes gave an average of 2.44 ± 0.0380 more but 7.16 ± 0.8838 sq. cm. smaller leaves than the nonbearing ones. Similarly, the lateral bearing outnumbered the nonbearing flower flushes by 2.57 ± 0.0374 although the leaves were 10.46 ± 0.8727 sq. cm. smaller. However, when the total leaf area was taken into consideration, the bearing in either case had more than the nonbearing flower flushes.

6. The bearing twigs and flower flushes either terminal or lateral in the different cardinal directions were longer, more stocky and had greater total leaf area than the corresponding nonbearing parts.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. A cashew bearing twig with flower flush and basal part of flower.
2. A cashew nonbearing twig with flower flush. The leaves were cut off to show the bases of measurements.
3. A cashew leaf.

POLYEMBRYONY IN CITRUS AND STUDY OF HYBRID SEEDLINGS

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The purpose of this study is fourfold: to present the embryo counts of different species and varieties; to determine the relation between the embryo counts and the seedling counts; to present the description of hybrid seedlings based on juvenile characteristics in contrast with the non-hybrids or apogamous seedlings of the seed parents; and to show the effect of different pollen upon the percentages of hybrids produced.

The study was started during the fruiting season of 1928 in the Tanauan Citrus Station, Tanauan, Batangas, where most of the embryo counts were taken. Later, in 1933 to 1935, the work was conducted in the Los Baños Economic Garden, Los Baños, Laguna, where some of the embryo counts were obtained and most of the seeds of different varieties and crosses were grown for the study of hybrids and nonhybrid seedlings.

The data presented for the study of embryo counts and seedling counts were gathered particularly to determine the most suitable seed parent varieties for hybridization. It was Frost (1) who had shown experimental evidence indicating that varieties producing the least number of adventitious embryo are the more economical to use as seed parent in hybridization, declaring that embryo counts often give valuable indication in this connection.

It is, therefore, obvious that in the breeding of citrus the presence of multiple embryos in the seed is of considerable importance. In a polyembryonic seed, it may be explained in passing, there are usually two kinds of embryos—the sexual embryo which is formed by fertilization or union of two parental gametes and the asexual embryos which develop without fertilization. Asexual embryos are called adventitious embryos or apogamic embryos, for they develop without the process of fertilization. The formation of the embryo from the egg cell without the sexual process is termed *ovogenic apogamy*, but when the embryos arise

from any somatic cells, the phenomenon is called *somatic apogamy.* In citrus the adventitious embryos are formed by the cells of the nucellus which enter the embryo sac and develop therein. This formation of buds in the embryo sac is termed by Sharp (2) *sporophytic budding.* The process is a natural way of vegetative propagation through the seeds.

According to Strassburger (3) the adventitious embryos develop from the nucellar cells and nearby tissues only after the stimulus of pollination or after what may be called partial fertilization. Osawa (4) has observed the same phenomenon in *Poncirus trifoliata* (*C. trifoliata*). Strassburger states that the presence of vigorous apogamous embryos in the seed may affect or completely prevent the development of the zygote or fertilized egg. Thus Webber (5) observed that some of the citrus hybrids such as the citranges and the tangeloes are oftentimes producing 100 per cent apogamic seedlings.

MATERIALS, METHODS, AND RESULTS

In the study of embryo counts, 126 samples were used. This number includes 14 samples representing 14 varieties of the species *Citrus maxima* (*C. grandis*) Osbeck, 8 of which were of the pomelo type and 6 of the grapefruit; 33 samples of different varieties of sweet oranges, *C. sinensis* Osbeck; 18 samples representing 15 varieties of the loose skinned oranges or mandarins, *C. nobilis* Lour. and 34 samples of different Batangas mandarin trees; and 28 samples represented as follows: *C. mitis,* 1 sample; *C. limonis,* 6 samples; *C. aurantium,* 4 samples; *C. aurantifolia,* 3 samples; *C. webberii,* 3 samples; *C. hystrix,* 2 samples; *C. longispina,* 1 sample; *C. marophylla,* 1 sample; *C. hybrid,* 3 samples; and 4 samples from unidentified varieties.

Each seed sample for the study of embryo counts consisted of 50 normal seeds; each sample was taken at random from a large amount of seeds freshly extracted from the ripe fruits. Before taking the samples, the seeds were first washed thoroughly to remove the slimy substances adhering to the seeds. Then the seeds were air-dried for a few hours.

The seeds were examined individually after removing carefully, first the outer seed coat, then the inner seed coat. Afterwards, the embryos were carefully separated from each other, each with its cotyledons, by means of a pair of home-made bamboo forceps having blunt points. A hand lens was used

to examine the embryo as it is attached to the cotyledons. The results of embryo counts are shown in Tables 1 to 5, inclusive.

In the study of seedling counts of eleven varieties, mostly seeds of the parent varieties and no less than 52 different crosses were used. Of the crosses, there were 26 *C. nobilis* crosses, 13 *C. maxima* crosses, 1 *C. aurantifolia* or lime crosses, and 12 interspecific crosses. The results are shown in Tables 6 and 7.

The seeds of each variety or cross were sown in seed boxes made out of halves of petroleum boxes cut longitudinally. The citrus seeds were sown at the rate of about 75 seeds in each box, giving a space of about 3.6 square inches per seed, an ample space for the development of the seedlings for several weeks. The number of seeds which germinated was noted and the seedlings which developed from each seed were counted.

In the case of crossed seeds the seedlings are allowed to develop for a reasonable length of time until the hybrid seedlings could be differentiated from this sister-apogamic seedlings. This period may take about one to five months after the date of sowing.

RESULTS OF EMBRYO COUNTS

Pomelos and grapefruits.—The embryo counts given in Table 1 present a striking difference between the pomeloes and the grapefruits. All the pomeloes were uniformly monoembryonic whereas the grapefruits were more or less polyembryonic. The variety Walter P. I. No. 4118 gave the highest mean, 2.86 ± 0.59 embryos per seed. These observations suggest that in the hybridization between these two types or between pomeloes and other species the pomeloes should be used exclusively as seed parents. Seedlings produced from monoembryonic varieties are sexual seedlings and the seeds of this type when crossed will produce only hybrid seedlings.

The common knowledge is that the grapefruits produce relatively smaller fruits with thinner skin and in most cases having a slightly bitter taste. These characteristics may oftentimes distinguish the grapefruits from the pomeloes, but the embryo counts seem even stronger evidence that would differentiate these two groups of citrus which are commonly classified under one species, *C. maxima,* synonymous to *C. decumana* or *C. grandis,* Osbeck. The grapefruits have been named *C. decumana* var. *ovucarpa.* Inasmuch as the embryo counts seem to point out strongly that these two groups of citrus, the pomeloes and the grapefruits, are very distinct forms from each

TABLE 1.—*Embryo counts in Citrus grandis Osbeck (C. maxima), pomeloes and grapefruits*

P. I. No.		Seed distribution for number of embryos							Total embryos	Mean embryos
		1	2	3	4	5	6	7		
6005	Chinese pomelo	50							50	1.00
8861	La Union pomelo	50							50	1.00
	Los Baños pomelo	50							50	1.00
7410 B	Nueva Ecija pomelo	50							50	1.00
1633	Pink pomelo	50							50	1.00
3384	Saigon pomelo	50							50	1.00
3442	Sinsemi pomelo	50							50	1.00
3673	Siamese pomelo	50							50	1.00
1333	Ellen Grapefruit	36	12	2					56	1.32±0.23
5703	Panuban grapefruit	43	6	1					58	1.16±0.17
3882	McCarthy grapefruit	27	13	8	2				85	1.70±0.34
1631	Marsh grapefruit	31	15	4					73	1.46±0.30
1713	Triumph grapefruit	43	5	2					59	1.18±0.22
4118	Walter grapefruit	4	19	15	6	4	2		143	2.86±0.59

TABLE 2.—*Embryo counts in Sweet oranges, Citrus sinensis Osbeck*

P. I. No.	Variety name	Distribution for number of embryos												Total embryos	Mean embryos	P. Em.
		1	2	3	4	5	6	7	8	9	10	11	12			
1720	Bahia	37	10	3										66	1.32	±0.02
3660	Balanga	32	14	4										72	1.44	±0.30
2698	Boone	33	11	6										73	1.46	±0.33
8856	Boot	14	18	11	2	2	1	2						121	2.42	±0.70
2695	Brown navel	13	8	7	5	10	2	4	1					168	3.3	±0.97
966	Cajel	14	15	5	10	5	1							130	2.60	±0.70

| | | |

TABLE 3.—*Embryo counts in loose skinned oranges, Citrus nobilis*

P. I. No.	Variety Name	Seed distribution for number of embryos						Total embryos	Mean embryos
		1	2	3	4	5	6		
8865	Batangas	15	20	10	5			105	2.01±0.45
1265	China	1	16	19	2	1	1	109	2.72±0.44
1918	Dancy	20	21	8	1			90	1.80±0.36
2693	King	45	5					55	1.10±0.14
2693	King	43	4	3				61	1.22±0.25
2693	King	42	7	0	1			60	1.20±0.25
1271	Kishiu	49	1					51	1.02±0.07
10149	Kosho Tan Kan	22	15	10	3			94	1.88±0.44
1256	Ladu	1	24	19	4	2		132	2.64±0.39
1335	Oneco	23	15	12				89	1.78±0.38
1262	Suntara (common)	20	27	3				83	1.66±0.26
1267	Szinkom (big)	19	22	7	2			92	1.84±0.32
1269	Szinkom (small)	24	22	4				80	1.60±0.30
5183	Tison (Malvar)	29	13	6	1	1		82	1.64±0.43
5143	Tison (Rafael)	8	16	21	5			123	2.46±0.42
8862	Tison	25	19	5	1			82	1.64±0.35
9896	Calamandarin	29	18	2	1			75	1.50±0.31
5173	Saagkam	14	19	9	6	2		113	2.21±0.52

TABLE 4.—*Embryo counts in seeds from different trees of Batangas mandarin*

Tree number	Distribution for number of embryos										Total embryos	Mean embryos
	1	2	3	4	5	6	7	8	9	10		
B88		10	19	8	7	5	1				181	3.62±0.63
S31		15	23	9	3						150	3.00±0.40
A7	1	15	23	8	3						147	2.94±0.41

B114	2	13	26	8	0	1		144	2.88±0.40
B306	3	11	16	15	3	2		160	3.20±0.53
B152	4	19	15	9	2	1		139	2.78±0.52
B44 (a)	4	21	20	4	1			127	2.54±0.39
B154	4	23	17	3	1			122	2.44±0.38
B158	4	29	10	5	2			122	2.44±0.44
5R7 (NMO)	4	30	13	3				115	2.30±0.34
B44 (b)	6	12	16	9	5	1	1	152	3.04±0.60
B157	6	28	12	3	1			115	2.30±0.38
B111	7	28	16	3				115	2.30±0.37
A15	7	31	10	2				107	2.14±0.33
B257	8	14	20	4	3	1		133	2.66±0.54
B304	8	24	12	5	1			117	2.34±0.44
B313	9	13	16	6	4	2		139	2.78±0.63
B112	10	28	10	1	0	1		106	2.02±0.42
B247	11	16	13	5	4	1		128	2.56±0.60
A24	12	23	14	1				104	2.08±0.36
7R7 (NMO)	12	25	13					101	2.02±0.33
A23	12	26	10	2				102	2.04±0.36
A16	13	22	9	4	2			110	2.20±0.49
A82	13	28	7	1	1			99	1.98±0.38
B110	14	18	12	4	2			112	2.24±0.51
8R7 (NMO)	15	20	10	5				105	2.01±0.45
A6	15	22	10	3				101	2.02±0.41
A21	15	26	9					94	1.88±0.31
B279	15	27	8					93	1.86±0.28
A3	16	20	12	2				100	2.00±0.40
B113	17	24	8	1				93	1.86±0.35
B135	18	16	11	1	2	2		109	2.18±0.59
B163	18	14	12	5	1			107	2.14±0.51
24R7	26	15	6	2	1			87	1.74±0.45

TABLE 5.—*Embryo counts in other citrus species and varieties*

P. I. No.	Variety name	Distribution for number of embryos										Total embryos	Mean embryos
		1	2	3	4	5	6	7	8	9	10		
10,159	*Citrus mitis*												
	Calamonding	2	1	4	8	15	7	7	3	2	1	266	5.32±0.88
7,217	*Citrus limonia*												
	Rough lemon	7	15	16	3	6	3					145	2.90±0.66
	Rough lemon	20	19	10	1							92	1.84±0.38
	Rough lemon	28	20	2								74	1.48±0.27
1,712	Thornless lemon	39	10	1								62	1.24±0.22
8,870	Eureka lemon	38	10	1	1							65	0.28±0.28
692	Villafranca lemon	33	11	3	3							76	1.52±0.41
	Citrus aurantium												
1,638	Sour orange	48	2									52	1.04±0.09
2,511	Florida sour orange	47	2	1								54	1.08±0.16
7,142	Sour orange	41	9									59	1.18±0.18
Seedlings	Sour orange	50										50	1.00
	Citrus aurantifolia												
	Carabao lime	50										50	1.00
5,184	Kussaie lime	40	10									60	1.20±0.16
	Native lime	50										50	1.00
2,275	*Citrus webberri*	19	22	3	6							96	1.92±0.45
2,363	*Citrus webberri*	19	16	10	2	3						104	2.08±0.52
5,102	*Citrus webberri*	17	23	8	0	2						97	1.94±0.44
834	*Citrus hystrix*	50										78	1.56±0.28
807	Cabuyao	25	22	3								99	1.98±0.40
2,528	*Citrus longispina*	13	29	5	2	1						89	1.78±0.29
	Citrus macrophylla												
4,828	Alemow var.	16	29	5									

| | | |

other, together with some other botanical differentiation, the grapefruits may, therefore, be named *C. ovucarpa* to differentiate it henceforth from the pomeloes, *C. grandis* Osbeck.

Sweet oranges (*C. sinesis*).—From the data in Table 2, it is apparent that the sweet oranges are polyembryonic. The mean embryos per seed varied from 1.32 ± 0.02 of the variety P. I. No. 1720, Bahia to 4.88 ± 1.12 of the variety P. I. No. 9900, Aguilar. The mean for the 32 varieties studied is 2.63 ± 0.32 embryos per seed.

TABLE 6.—*Comparison between mean embryos and mean seedlings per seed in some citrus varieties*

Varieties	Mean embryos	Mean seedlings	Mean difference	Per cent (of embryo) seedlings
Kishiu	1.02±0.07	1.00	0.02±0.07	98
King mandarin	1.10±0.14	1.03±0.08	0.07±0.16	94
Triumph grapefruit	1.18±0.23	1.08±0.13	0.10±0.26	92
Ellen grapefruit	1.32±0.26	1.20±0.05	0.12±0.26	91
Tison mandarin	1.64±0.43	1.08±0.12	0.56±0.44	76
McCarthy grapefruit	1.70±0.42	1.23±0.20	0.47±0.46	72
Szinkom mandarin	1.78±0.41	1.38±0.26	0.40±0.49	76
Batangas mandarin	2.01±0.45	1.23±0.20	0.77±0.58	61
Ladu mandarin	2.64±0.39	1.78±0.33	0.86±0.51	67
China mandarin	2.72±0.40	1.42±0.34	1.30±0.51	52
Rough Lemon	2.90±0.66	2.00±0.47	0.90±0.81	69

According to the results of Frost's (1) investigations, oranges are the poorest in the production of hybrid seedlings when used as seed parents. In view of the fact that sweet orange varieties are very similar to each other in their seedling characteristics, hybridization within the species, therefore, becomes too problematical for it would be possible to differentiate the hybrids from the nonhybrids of the same cross only after they have produced fruits, and for that reason, it will require not only much time but also a large number of plants to test for hybrid sorts. All indications show that in the hybridization work with other species, the oranges will serve better as pollen parent than otherwise.

Mandarins (*C. nobilis*).—The 15 different varieties of *C. nobilis* have exhibited great variations in their embryo counts, Table 3. The mean embryos per seed varies from 1.02 ± 0.07 of the variety P. I. No. 2693 King, to 2.72 ± 0.44 of the variety P. I. No. 1263 China. The King and Kishui mandarins are notably the least polyembryonic types, and accordingly, in the

TABLE 7.—*Showing number of seedlings per hundred seeds and percentages of hybrid seedlings based on the number of seeds giving seedlings*

Cross number	Parent varieties		Number of seeds giving seedlings	Total seedlings	Number of seedlings per 100 seeds	Number of hybrid seedlings	Per cent (of seed) hybrid seedlings
	Seed	Pollen					
1	Calamonding	Ladu	143	270	188	60	41.0±2.7
2	Calamonding	Szinkom	40	90	225	18	45.0±5.3
3	China	Batangas	160	327	204	69	43.1±2.7
4	China	King	122	233	199	57	46.7±3.0
5	China	Tison	152	308	203	25	16.5±2.4
6	King	Batangas	336	360	107	336	100
7	King	Calamandarin	223	227	102	223	100
8	King	Dancy	563	576	102	563	100
9	King	Ladu	280	289	101	280	100
10	King	Saagkam	120	128	107	120	100
11	King	Szinkom	43	43	100	43	100
12	King	Tison	123	125	102	125	100
13	Kishiu	Batangas	110	110	100	100	100
14	Kishiu	China	33	33	100	33	100
15	Kishiu	Dancy	107	107	100	107	100
16	Kishiu	King	37	37	100	37	100
17	Kishiu	Szinkom	24	24	100	24	100
18	Kishiu	Tison	4	4	100	4	100
19	Kussaie	Native lime	13	13	100	13	100
20	Ladu	Batangas	267	582	214	71	26.5±0.1
21	Ladu	King	66	155	235	25	37.8±4.0
22	Ladu	Kishiu	67	186	278	20	29.9±4.7
23	Ladu	Szinkom	156	248	172	49	31.4±2.4
24	Saagkam	Tison	30	30	100	30	100
25	Szinkom	Batangas	319	499	156	91	28.5±1.7
26	Szinkom	Calamonding	162	292	186	27	16.6±2.0
27	Szinkom	China	156	248	159	49	31.4±2.5
28	Szinkom	King	103	146	142	36	34.9±3.1
29	Szinkom	Ladu	598	857	143	79	13.2±0.9
30	Szinkom	Laurel orange	96	161	168	15	15.6±2.4
31	Szinkom	Tison	130	167	128	48	36.9±2.8
32	Panuban Gft	McCarthy Gft	70	78	111		
33	Pink pomelo	La Union pom.	82	82	100	82	100
34	Pink pomelo	Marsh Gft.	136	136	100	136	100
35	Pink pomelo	Panuban Gft.	6	6	100	6	100
36	Pink pomelo	3442 Siamese	181	181	100	181	100
37	Pink pomelo	3673 Siamese	103	103	100	103	100
38	Rough lemom	Sour orange	819	1,607	196		
39	Sour oragne	Rough lemon	319	385	121		
40	Villafranca l.	Bahia orange	21	22	105	15	70.4±6.7
41	Villafranca l.	Kussaie lime	79	129	137	7	8.8±2.1
42	Villafranca l.	N. Ecija pom.	72	82	114	39	54.1±3.9
43	N. Ecija pom.	3442 Pomelo	416	416	100	416	100
44	3442 Siamese	Duncan Gft.	108	108	100	108	100
45	3442 Siamese	Florida S. Or.	62	62	100	62	100
46	3442 Siamese	Laurel orange	82	82	100	82	100
47	3442 Siamese	Marsh Gft.	45	45	100	45	100
48	3442 Siamese	Panuban Gft.	93	93	100	93	100
49	3442 Siamese	Pink pomelo	394	394	100	394	100
50	3442 Siamese	Saigon pomelo	62	62	100	62	100
51	3442 Siamese	Vermilion pom.	74	74	100	74	100
52	3673 Siamese	King	108	108	100	108	100

N. B: l.=lemon; pom.=pomelo; or.=orange; Gft.=grapefruit.

hybridization of mandarins the King and the Kishui varieties would serve better as seed parents than any of the other varieties for the same purpose.

The Ladu and China mandarins are both highly polyembryonic. In the selection of varieties for stock purposes, Webber (4) is of the opinion that citrus varieties that are highly polyembryonic are the ones producing a large number of apogamic seedlings that are almost uniform genetically and of the same phenotype. The fact that these two varieties of mandarins, Ladu and China, are highly polyembryonic, their value as stocks in the Philippines may be tried.

The embryo counts which are obtained from 34 Batangas mandarin seedling-trees, Table 4, showed that the Batangas mandarin is polyembryonic; nevertheless, the individual trees exhibited some variations in their mean embryos per seed. It is now obvious that being highly polyembryonic, and its fruits, for having very loose articulation, are susceptible to windfall, the Batangas mandarin is not suitable for use as seed parent in hybridization. In this connection, it might be mentioned that this mandarin has been used as a general stock for the propagation of many varieties and species of citrus in Government stations, but the selection of trees from which to get uniform seedlings for stock purposes has not been given any attention. In Table 4, it can be seen that trees B44(b), B83, B306, S7, and S31 have the highest embryo counts. They might prove superior to other trees as seed parent for the production of seedling stocks. Needless to say the relative vigor and variability of the seedlings from these trees as well as their effects upon the buds or scions should be carefully studied.

Other species and varieties of citrus.—The calamonding, *C. mitis,* Table 5, is very highly polyembryonic, the mean embryos per seed being the highest, 5.32 $\pm$ 0.88 embryos. Although the seedlings of this species are vigorous and uniform on account of the production of a large number of adventitious buds, the test as stocks for mandarins and sweet oranges did not show satisfactory results. In both cases, the scions overgrew the stocks and in many cases with sweet oranges, the trees died in 10 to 12 years from transplanting. As seed parent for hybridization, the calamonding is of doubtful value in so far as embryo count is concerned.

Of the 4 varieties of lemons, *C. limonia,* the rough lemon gave the highest embryo count, indicating that this variety should

be used as pollen parent in the hybridization of lemons. This variety, having a greater resistance to diseases than the other lemon varieties, is suitable for stock purposes. Like the Batangas mandarin, the rough lemon has been used as a general stock, but so far experience shows that it excels any other stocks for calamonding scion.

The sour orange, *C. aurantium,* is partly polyembryonic much like the King and the Kishui mandarins. Since the greater portion of its seeds is monoembryonic the sour orange may be used as seed parent in hybridization. As compared with the embryo counts in sweet oranges, the data show that the sour orange is indeed a different type.

Of the *C. aurantifolia,* the carabao lime and the native lime are both monoembryonic, whereas the Kussaie is partly so. The embryo counts indicate that in hybridization the lime would be more economical than lemon to use as seed parent. Among the so-called *C. hystrix,* P. I. No. 834, is a wild species of citrus producing smooth, flat fruit of medium size with somewhat thinner rind than that of the grape-fruit. The seeds are flat and of monoembryonic type. The other form, P. I. No. 807, the cabuyao or colobot, with a rough or corrugated rind, is 50 per cent polyembryonic. Repeated observations showed the same results. Thus, it can be inferred that one is a distinct type from the other, perhaps a different species.

Other species of citrus.—All the three samples of *C. webberii,* different P. I. numbers, are polyembryonic. They are undoubtedly identical type. The *C. longispina,* P. I. No. 2528, which is characterized by the presence of extra long spines, throughout the whole plants from the trunk to the lateral branches, is also polyembryonic as well as the P. I. No. 4828, *C. macrophylla,* which is characterized by large leaves. The citrus hybrid, a cross, tangerine × grapefruits, named tangelo, as shown by three different samples examined, is a polyembryonic form. The other unidentified forms, such as the Dayday, Natsu Daidai, Kabusa, and the Igorot orange are all polyembryonic types.

SEEDLING COUNTS IN RELATION TO EMBRYO COUNTS

It is noteworthy to show the comparison between the mean embryos and mean seedlings per seed of some of the seed-parent varieties. In Table 6 it can be seen that the mean seedlings are in all cases, less than the corresponding mean

embryos indicating that under the condition in which the seeds were sown, some of the embryos were weak and small, and it is mostly this class of embryos that had failed to grow. However, the differences in favor of the mean embryos are statistically insignificant.

The last column of Table 6 shows the percentage of embryos which have grown and developed into seedlings. The percentage of (embyro) seedlings is inversely proportional to the size of mean embryo. It is obvious that the more embryos there are in the seeds, the more are the embryos that are weak and the less percentage of seedlings produced.

DESCRIPTION OF HYBRID SEEDLINGS

Just as there are two kinds of embryos in the seeds so are there two kinds of seedlings produced, the apogamous seedlings and the sexual seedlings. Thus, the recognition at the early stage of one class of seedlings from the other is a matter of considerable importance.

The author (6) in one of his previous reports stated that the citrus hybrid seedlings usually are of intermediate forms between the parent varieties. The basis for differentiation may be one or more characteristics such as size and shape of seedleaves (cotyledons), size and shape of juvenile leaves including shape and position of apex, serration of leaf edge, size and shape of wings of the petiole, length of petioles, vigor of the seedlings, and the nature or development of the root system. These comparative descriptions of hybrids and nonhybrids or parental types of seedlings are based on transient qualities, for some of them will disappear and others will change as the plants advance in age. In order to take advantage of these rather temporary characteristics, it requires a frequent critical and thorough examination at the early stages of the seedlings.

Calamonding (*C. mitis*) *crosses.*—The calamonding as shown by the embryo counts is a highly polyembryonic form of citrus. In fact, it has the highest embryo count of all the citrus studied. The apogamous seedlings are very vigorous whereas the hybrids resulting from its crosses with the Szinkom and Ladu are much less vigorous than the calamonding apogamous seedlings.

The calamonding × Szinkom hybrids are of intermediate types between the two parents, such that they can be selected out without much difficulty. They differ in type and texture of leaves and the petioles are somewhat longer than that of the nonhybrid calamonding. On the other hand, the calamonding

× Ladu hybrids are almost similar to the apogamous seedlings of the seed parent. Only a closer examination has revealed their distinctions. The apex of the leaves resembles that of the ladu and the petiole is slightly shorter than that in calamonding being influenced by the ladu pollen parent.

China (*C. nobilis*) *crosses.*—The hybrid seedlings from China × King and China × Tison crosses are very vigorous, in fact more vigorous than the apogamous seedlings of the seed parent, indicating a pronounced effect of heterosis or hybrid vigor. The root systems are better developed and the leaves are broader and the winged petioles are prominently wider than the apogamous China seedlings.

The cross China × Batangas produced hybrids that are almost similar to the apogamous China seedlings with respect to the size, shape and position of the leaves and petioles but the seed leaves (cotyledons) in the hybrids are broader, parted at the apical end and somewhat irregular in shape or lop-sided, very similar in appearance to those of the apogamous Batangas seedlings. The hybrids are also vigorous but the effect of heterosis is less pronounced than in the other two crosses.

King (*C. nobilis*) *crosses.*—Although the King mandarin is almost a monoembryonic variety as evidenced by its embryo count, the seedlings from the selfed seeds are very variable. Some seedlings produce more or less broad leaves while others have smaller and narrower leaves. Generally the seedlings are weak, having very poor root system.

On the other hand, most of the hybrid seedlings from the different crosses are far more vigorous than the seedlings from the selfed seeds. The root systems in these hybrids are greatly improved. Very few apogamic seedlings were found in many of these crosses. This rarity of apogamous seedlings is to be expected from an almost monoembryonic seed parent as the seedlings from monoembryonic seeds are sexual seedlings which, when crossed, produce only hybrid seedlings.

Kishiu (*C. nobilis*) *crosses.*—The selfed seeds of Kishiu produced several types of seedlings, namely, (*a*) the normal seedlings; (*b*) the narrow leaf type; and (*c*) the intermediate forms between (*a*) and (*b*); and (*d*) the white seedlings. The narrow-leaf and the white seedlings are abnormal and very weak forms. The whites lack chlorophyll and soon die after germination while the narrow-leaf seedlings remain alive a little longer, from two weeks to two months. The normal seedlings type (*a*) have broad leaves, a little longer than its

width, while those in group (*c*) have a bit narrower or more slender leaves. Like the seedlings of King mandarin, the Kishiu seedlings have weak root systems; so neither the King nor the Kishiu is suitable for stock purposes.

In the light of the present observation with the selfed seeds and the seedlings therefrom, the Kishiu and the King mandarins are both heterozygous materials.

The hybrid seedlings from the Kishiu × Batangas and Kishiu × China crosses appeared very much alike, although a closer examination showed that the Kishiu × China hybrids have a bit narrower leaves. The hybrids from the Kishiu × Dancy are characterized by the pointed apical portion of the leaves which is also slightly folded resembling the leaves of the Dancy variety, the pollen parent. The Kishiu × King hybrids are mostly identical to those from the reciprocal cross, having much wider leaves and broader winged petioles than the Kishiu parent. The Kishiu × Szinkom hybrids have leaves that closely resemble those of the Szinkom except that the leaves of the hybrids are a little broader toward the base and the petioles are noticeably shorter than those of the apogamous Szinkom seedlings. The cross of Kishiu × Tison produced hybrids that resemble Kishiu × King hybrids in having broad leaves and wide winged petioles although the former produced much longer spines.

Ladu mandarin (*C. nobilis*) *crosses*.—The seedlings raised from the selfed seeds of Ladu mandarin are more or less uniform with well developed root system. These seedlings, being from a polyembryonic parent, are mostly apogamous.

The Ladu × Batangas hybrid seedlings are more vigorous than the apogamous Ladu seedlings. The hybrids have pointed apices of the leaves. The outline of the apical portions of these leaves which appear narrow and somewhat folded as viewed from top, form the chief differentiating characteristic that facilitate the isolation of hybrid seedlings from the apogamous ones. The Ladu × King hybrids are still more vigorous than those from the first cross. The leaves and the winged petioles are broader than those of the sister apogamic seedings. The Ladu × Kishiu hybrid seedlings although not so vigorous, can be distinguished from the nonhybrid without the least difficulty as the leaves of the hybrids are narrower and longer than those of the apogamic Ladu seedlings. In the nature, size and shape of leaves, the Ladu × Szinkom hybrids closely resemble the Ladu × Kishiu hybrids, nevertheless the Ladu × Szinkom

hybrids are less vigorous than either the Ladu nonhybrid seedlings or Ladu × Kishiu hybrids. The last two are almost of equal vigor in the seedling stage.

Saagkam (*C. nobilis*) *cross.*—The seedlings produced from selfed and naturally pollinated seeds of Saagkam are weak with as poorly developed root system as those in the seedlings of selfed King and Kishiu. The hybrids, Saagkam × Tison produced leaves that are intermediate in size and shape and the long spines are not absent in the hybrids.

Szinkom (*C. nobilis*) *crosses.*—The selfed seeds of Szinkom gave two kinds of seedlings, the normal and the white ones. The white seedlings, as the Kishiu white seedlings, lack green chlorophyll and died out in a week or two after germination. These white seedlings were not observed in any of the Szinkom crosses. The leaves of the normal seedlings are in general almost twice as long as their width, with narrow apices and are tapering toward the base. The narrow winged petioles are rather long.

The Szinkom × Batangas hybrids have broad leaves and the winged petioles are shorter but wider than those of the nonhybrids Szinkom seedlings. Although as vigorous as the apogamous Szinkom seedlings, the hybrids can be easily picked out. The Szinkom × King hybrids have still broader leaves and wider winged petioles than the Szinkom × Batangas hybrids. The Szinkom × Tison hybrids are very similar to the Szinkom × King hybrids with respect to type of leaves but the Szikom × Tison hybrids have the characteristic long spines of the Tison which may either become reduced or lost out completely as the hybrids become older. Like the Szinkom × Tison, the Szinkom × China hybrids are very vigorous, outgrowing the apogamous Szinkom seedlings by a very wide margin, so that the selection of the hybrid seedlings in these two crosses is quite easy. The leaves of the Szinkom × China are smaller than the leaves of the Szinkom × Tison and Szinkom × King hybrids but are considerably broader or wider than those of the apogamous Szinkom seedlings.

The Szinkom × Ladu hybrids closely resemble the hybrids of the Szinkom × Batangas and the Szinkom × China, as to the appearance of the young seedlings, and in the type of leaves. But the Szinkom × Ladu hybrids seem less vigorous than any of the other hybrids and the apogamous Szinkom seedlings.

The Szinkom × calamonding hybrids are as weak as those from the reciprocal cross. However, both make good growth

after pricking or planting in the nursery rows. The leaves are wider with more rounded apical portion and slightly shorter but wider winged petioles than the Szinkom parent. The Szinkom × Laurel hybrids have much wider and longer leaves and are far more vigorous than the Szinkom nonhybrid seedlings. Long and large spines are formed in the hybrid seedlings, inheriting the spiny characteristics of the sweet orange seedlings.

Tison (*C. nobilis*) *cross.*—The Tison seedlings from the selfed seeds appear quite uniform and most of them possess long spines. The Tison × Ladu hybrids are more vigorous than the Tison seedlings with narrower leaves and narrower winged petioles. Long spines are present in the hybrids as in the Tison seedlings and other hybrids where Tison was used either way.

Pomeloes and grapefruits crosses.—It was made known by the embryo counts that the grapefruits are to a certain extent polyembryonic, whereas the pomeloes are uniformly monoembryonic. For that reason the seedlings raised from any crosses in which the pomeloes are used as seed parents are all hybrid seedlings. The problem, therefore, is no longer in differentiating the hybrids from the nonhybrid seedlings but rather in the selection of the most vigorous seedlings for transplanting, propagation, and further selection.

The hybrids from pomelo crossed with other species such as P. I. No. 3442 × Florida sour orange (*C. aurantium*), P. I. No. 3442 × Laurel orange (*C. sinensis*) and P. I. No. 3673 × King mandarin (*C. nobilis*) are of intermediate types between the two parental varieties. The P. I. No. 3442 × Laurel orange hybrids showed well developed spines while the P. I. No. 3673 × King hybrids have a medium sized and somewhat thinner leaves.

Villafranca (*C. limonia*) *crosses.*—Like mandarins and oranges, the lemons are polyembryonic; hence they produce a large number of apogamous seedlings. Crossed with other lemons as in Villafranca × Rough lemon, the hybrids are difficult to distinguish from the nonhybrids; nevertheless, in the reversed cross, the selection is somewhat easier for the color of young shoots in Villafranca as may be seen in some of the hybrid seedlings. The young shoots of rough lemon seedlings are green.

The hybrids of Villafranca × Nueva Ecija pomelo produced large and long pointed leaves with broadly winged petioles. These hybrids possess long spines but the apogamous Villafranca

seedlings are spineless or with very few short and small spines and the petioles are wingless. The Villafranca × Bahia orange hybrids possess somewhat thicker but smaller leaves than the leaves of lemons, closely resembling that of Tahiti lime in some cases. In the hybrids, Villafranca × Kussaie lime the leaves are narrower than the leaves of the Villafranca but are much longer and larger than the leaves of the Kussaie. In all of these cases, the Villafranca hybrids are distinct forms from either of the parents so that they can be easily singled out from the nonhybrid form.

Sweet oranges (*C. sinensis*).—Seedlings from the different varieties of oranges look very much alike, consequently the hybrid forms from the crosses between varieties are hard to identify from the apogamous ones. No attempt has been made to cross oranges with other species using them as seed parent, but some crosses with oranges as pollen have been made. Pollen of different varieties such as Du Roi, Dougat and Laurel oranges have been tried with King mandarin, Szinkom mandarin and Siamese pomelo. The results so far showed the possibility of producing hybrid seedlings; those of the Szinkom × Laurel and P. I. No. 3442 Siamese pomelo × Laurel have already been described. Up to the present writing, King crosses with oranges are still in the fruit, soon to be harvested.

PERCENTAGES OF HYBRID SEEDLINGS

It was noted in some varietal crosses, such crosses in which both varieties involved appear quite similar in the seedling stage, that the resulting hybrids are not recognizable from the apogamous seedlings of either parents. This has been observed in crosses between varieties of oranges and those between some varieties of lemons. There are some matings in which the hybrids may be easily distinguished from the apogamous seedlings of the seed parents, but not so in the reversed mating. Crosses in which the results are doubtful as to the identity of the hybrid progeny have been eliminated from the study on the percentages of hybrid seedlings.

Besides, it is well known that citrus in general are more or less heterozygous materials so that the F_1 hybrids from any cross may be expected to show certain degree of variability. In the study of young seedlings, it is obvious that those hybrids distinctly at variance with the common apogamous seedlings of the polyembryonic seed parent can easily be separated. On

the other hand, with varying F_1 hybrids, those closely resembling the nonhybrid forms from the same cross might have been taken, in a few cases, as apogamous seedlings. Let it be remembered that the hybrid counts here considered refer only to the hybrid seedlings that have shown some positive characteristics of hybridity at the seedlings stage. The data obtained from this study are given in Table 7.

From this table, it can be seen that the Kishiu mandarin, King mandarin and all the pomeloes have produced 100 per cent hybrid seedlings or one hybrid to every crossed seed giving seedlings while the polyembryonic seeds parents gave varying percentages of hybrid seedlings.

The calamonding crossed with Ladu and Szinkom gave 41.0±2.7 per cent and 45.0±5.3 per cent hybrids, respectively. The China mandarin crossed with Batangas, King and Tison showed 43.1±2.7, 46.7±3.0 and 16.5±2.4 per cent hybrids, respectively. There has been observed less percentages of hybrids with Tison as pollen parent, indicating that the percentage of hybrids in any cross depends upon the kind of pollen used in its affinity toward the ovaries of the seed parent.

The Ladu × Batangas cross gave 26.5±0.1 per cent hybrids; the Ladu × King 37.8±4.0 per cent; the Ladu × Kishiu, 29.9±4.7 per cent, and the Ladu × Szinkom, 31.4±2.4 per cent hybrids. Note that their differences are not statistically significant, indicating that the four varieties used as pollen are of equal strength in impregnating the ovaries of the Ladu parent.

On the other hand, the Szinkom mated with the Batangas, China, King, and Tison showed, respectively, 28.5±1.7, 31.4±2.5, 34.9±3.1 and 36.9±2.8 per cent hybrids, while with the same seed parent crossed with calamonding, Ladu and Laurel oranges the corresponding percentages of hybrid seedlings were 16.6±2.0 per cent, 13.2±0.9 per cent and 15.6±2.4 per cent. These data seem to indicate that the last three varieties are less effective to use as pollen for Szinkom than the other varieties used. Of course, it must be noted that the Szinkom is *C. nobilis*, while the calamonding and the Laurel orange are *C. mitis* and *C. sinensis*, respectively. Hence two out of the last three crosses are matings between different species.

The cross of Villafranca lemon × Bahia orange showed 70.4±6.7 per cent hybrids; the Villafranca × Kussaie lime, 8.8±2.1 per cent hybrids and the Villafranca × Nueva Ecija pomelo, 54.1±3.9 per cent hybrids. Due to the small number

of seeds giving seedlings from the first cross, its high percentage of hybrid seedlings cannot be credited fully, nevertheless, the pomelo was a better pollen for Villafranca than the lime in so far as the production of hybrid seedlings is concerned.

SUMMARY

Among different species and varieties studied for embryo counts, the monoembryonic forms are: all the pomeloes, a seedling sour orange tree, the carabao lime, the native lime and P. I. No. 834, *C. hystrix*. Those having 80 per cent upward of monoembryonic seeds, which may be used to advantage as seed parents in hybridization, are: of the *C. ovucarpa* or grapefruits, the 5103 Panuban, and the 1713 Triumph; of the *C. nobilis* Lour., the 2693 King and the 1271 Kishiu; of the *C. aurantium*, the 1638 sour orange, the 2511 Florida and the 7142 sour orange; of the *C. aurantifolia*, the 5184 Kussaie; and the 7406 Natsu Daidai.

The name *Citrus ovucarpa* for grapefruits is here suggested to distinguish them from the *C. grandis* Osbeck (*C. maxima* or *C. decumana*) the pomelo type. The embryo counts showed that all the pomeloes have only monoembryonic seeds, whereas all the grapefruits are polyembryonic to a less or greater extent.

Of the two so-called *C. hystrix* studied, the wild one, P. I. No. 834 with flat and smooth-rinded fruits is monoembryonic like the pomeloes, while the other P. I. No. 807 cabuyao or colobot having rough rind is polyembryonic. It appears that they are distinct types of different species.

It was shown that the percentage of embryos that develop into seedlings is inversely proportional to the number of embryos in the seeds. The conclusion drawn therefrom was that the greater the number of embryos in the seed, the more there were embryos that were weak and the more embryos which failed to develop into seedlings.

The differences between the mean embryos and mean seedlings per seed are not statistically significant.

Fourteen out of 52 different crosses showed strong manifestation of hybrid vigor or heterosis in the F_1 hybrids. These crosses are: China × Tison, China × King, King × China, King × Dancy, King × Ladu, King × Tison, Ladu × Batangas, Ladu × King, Szinkom × China, Szinkom × Tison, Szinkom × Laurel, Tison × Ladu, Kishiu × King and Kishiu × Tison. However, there are few crosses in which the hybrids are weaker

than the nonhybrid seedlings of either parents; these are: Calamonding × Szinkom, Ladu × Szinkom and sour orange × Rough lemon and their reciprocal crosses.

The study of hybrid seedlings showed that King mandarin, Kishiu mandarin and the pomeloes used as seed parents produced 100 per cent (of seed) hybrid seedlings, while the polyembryonic seed parents produced varying percentages of hybrid seedlings.

The percentages of hybrid seedlings from any seed parent may vary, depending upon the pollen varieties used. Based on the percentages of hybrids it was found that the Tison proved to be a weaker pollen for China mandarin than the Batangas and King mandarin and the Calamonding, Ladu and Laurel oranges as pollen for Szinkom are weaker than Batangas, China, King, and Tison; for Villafranca, the Nueva Ecija pomelo served as a better pollen than the native lime and for Siamese pomelo the King used as pollen was much stronger than the Kishiu mandarin. Any attempt at crossing Siamese pomelo with Kishiu did not develop into normal fruits.

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UTILIZATION OF FIRST FILIAL GENERATION HYBRIDS IN CROP IMPROVEMENT WITH SPECIAL REFERENCE TO TOBACCO

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FIVE PLATES AND TEN TEXT FIGURES

Hybrid vigor in plants was first observed about two centuries ago by Kolreuter. It was only in 1917, however, that the phenomenon was satisfactorily accounted for as being due to the complementary action of dominant factors, by Jones (1918), and then termed "heterosis" by him.

In the United States and Europe, especially among seed and plant dealers, hybrid vigor has long been utilized; but apparently, up to the present time, it has been neglected in the Philippines. The only instance of its application locally is the Alunan (Badila $\times$ P. O. J. 24) and P. S. A. 14 sugar cane. It is also manifested in some native fruits.

The utilization of hybrid vigor or heterosis is based chiefly on the established law of heredity to the effect that "*When pure races or strains are crossed, the population composing the first filial generation are similar to the parents in uniformity.*" This principle is mathematically expressed from the observation that if any particular factors XX and xx are pure or homozygous in the parents, only Xx individuals can be formed in the F_1 generation. In the first place, therefore, this law of heredity satisfies a primary essential in crop production—uniformity.

Because of heterosis the second primary essential in crop production—higher yield—is also obtained. Incidentally, other desirable qualities are at least retained if not enhanced.

The utilization of hybrids is generally practicable in the case of all plants that are reproduced asexually. Otherwise, it is subject to limitations which are primarily and obviously governed

by the facility of making the crossing, and the profitableness of the resultant yields of the crosses.

As regards crops, especially annual ones, reproduced or propagated only by seeds, the limitations are greater. Aside from those already given, the fact that the operation of crossing must be performed yearly in order to insure the supply of fresh seeds, limits the production of F_1 hybrid seeds to a few crops.

In the case of tobacco, a plant ordinarily produces 42 pods with a total of about 90,000 seeds. Since it takes only a half minute to cross a flower, in about half an hour the flowers of a plant can be crossed. Assuming only 75 per cent viability of the 90,000 seeds, one can grow about three hectares of tobacco from the seeds of one plant. Leaves produced from F_1 wrapper tobacco hybrids, namely, Vizcaya × Ilagan Sumatra, have actually sold for 8 pesos per kilogram.

FIG. 1. Leaves of F_1 plant—a cross between Samsoun Bafra and Conqueror; *a*, inflorescence leaf; *b*, middle standard leaf.

The advantages of F_1 hybrids are: (1) immediate result, (2) increased yield, (3) improved quality, (4) maximum uniformity, (5) higher seed viability, and (6) rapid growth.

Through hybridization followed by selection, it takes from four to twelve years to obtain uniformity, and even then, the question of yield cannot be guaranteed to equal that of the higher yielding parent, since homozygosity is synonymous to the absence of heterosis.

It is obvious that the best descendant of a cross cannot exhibit any trait superior to an identical trait of either parents.

The reason why annuals purchased from American and European seed dealers produce uniform and vigorous plants the first year and fail to repeat the performance the following year, is that they are really F_1 hybrids. Seed dealers in the continents do a good business because they possess the secret and the original races of the parents of the desirable F_1 hybrids. The original races are continually guarded inbred and at the same time fresh F_1 hybrids are produced yearly.

REVIEW OF LITERATURE

Hauser (1911) advocated the growing of first generation hybrids on commercial scale for the filler types of tobacco which are grown in Ohio.

East and Hayes (1912) reported that the first generation hybrids of many economic plants produced much greater yield than the pure strains. They recommend the production of F_1 hybrids on a commercial scale only on crops where crossing is easy.

Hayes (1912) found that the F_1 generation was intermediate in the characters he studied (number of leaves per plant, height of plant, average area of leaves, and length and width of leaves), and in general somewhat larger than the average of the parents. He further claimed that the F_1 generation is no more variable than the parents.

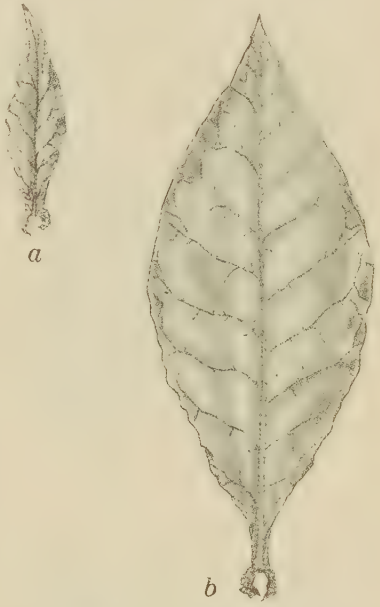

FIG. 2. Leaves of F_1 plant –a cross between Conqueror and Big Warne; *a*, inflorescence leaf; *b*, middle standard leaf.

Selby and Hauser (1912) in a carefully worked-out test found that the first generation hybrids in nearly all cases produced greater yield than the average of the parents. As to quality they believe that the F_1 generation will be more or less intermediate between those of the parents.

Hayes, East, and Beinhart (1913) found that "a good quality of leaf can generally be expected in a hybrid, if the parents are both of high quality, than if one parent is a good variety and the other somewhat lacking." Their results further showed that the F_1 generation of size crosses in tobacco are as uniform as the parents and of an intermediate value.

According to Hunter and Leake, Kosteff and Popoff (1932) found the F_1 generation lower than either parents in nicotine content.

Howard, in her studies on the time of flowering of the Indian types of tobacco (1913) and *N. rustica* (1924) found that in all cases the F_1 was intermediate. On the other hand she found that the F_1 plants were taller than either parent.

MATERIALS AND METHODS

Crosses made.—During the 1932-1933 season the following cigarette tobacco varieties were planted head-to-the-row of twenty-five plants each: Orinoco, Big Warne, Conquerror, and Samsoun Bafra. The best plant from each variety was selected to be used subsequently for hybridization. From the varieties mentioned above, the following crosses were made: Samsoun Bafra × Conqueror; Conqueror × Big Warne; Big Warne × Samsoun Bafra; Samsoun Bafra × Orinoco; Orinoco × Big Warne; and Conqueror × Orinoco.

Culture.—In the following tobacco season (1933–1934) seeds of the first filial generation hybrids and their parents were planted side by side at a distance of 80 by 70 centimeters at the central experiment station plot of the Bureau of Plant Industry in San Andres. The seeds were sown on October 10, 1933, in seed boxes. When the seedlings were about two weeks old they were pricked in beds previously prepared.

FIG. 3. Leaves of F_1 plant—a cross between Big Warne and Samsoun Bafra; *a*, inflorescence leaf; *b*, middle standard leaf.

From the time of sowing the seed to the time of harvesting the leaves, both the parents and the hybrids were given the same cultural treatment.

Characters studied.—There were five characters studied; namely, height of plants, number of leaves, breadth index of leaves, average yield per hectare, and period of maturity.

The height of the plants was taken when the capsules were already fully developed.

In determining the breadth index only one middle standard leaf from each plant was considered. The measurement was made when the leaf was already mature.

The average yield per hectare was computed for every individual plant, that is, the leaves were harvested separately from each plant as they became mature. After curing the leaves thoroughly the weight was taken. Hence, from the total weight of cured leaves for each plant the average yield per hectare was computed in terms of quintals.

The number of days from sowing the seed until the plants produced flower was considered as the period of maturity.

In the study of the characters enumerated above the mean standard deviation and coefficient of variability were determined in all cases.

DISCUSSION OF RESULTS

Height of plants.—Table 1 shows that in general the F_1 hybrids attained greater height than their parents. There is only one cross which did not excel both parents in height, i. e., Conqueror × Big Warne. It excelled the male parent but not the female parent.

The three crosses which attained the greatest heights are Big Warne × Samsoun Bafra, 173.00 ± 1.936 cm.; Samsoun Bafra × Conqueror, 168.00 ± 1.727 cm. and Samsoun Bafra × Orinoco, 160.60 ± 1.556 cm.

Using both the standard deviation and coefficient of variability as basis of comparison for this particular character, it seems that the varieties Conqueror and Samsoun Bafra are as uniform as, if not more uniform than some of, the crosses under consideration. On the other hand the varieties Big Warne and Orinoco are quite variable with standard deviation of 17.22 ± 1.642 and 20.88 ± 1.991 centimeters, respectively. The coefficient of variability of the hybrids ranges from 6 to 12 per cent.

FIG. 4. Leaves of F_1 plant—a cross between Samsoun Bafra and Orinoco; *a*, inflorescence leaf; *b*, middle standard leaf.

Table 6, where the crosses are directly compared with their respective parents concerning the characters under study, shows that the difference in height in favor of the hybrids is significant in nine cases out of twelve. The difference ranges from 1.60 ± 1.799 to 56.8 ± 3.117 centimeters. In only one instance did one of the parents excel the hybrid in height; namely, Conqueror × Big Warne, in which case Conqueror, the female parent, was 5.9 ± 3.066 centimeters taller.

In Table 7 the increase in height of the hybrids over the average of the parents ranges from 3.4 to 24.2 per cent. In all cases the hybrids gained in height. The percentage of increase in height of the hybrids over the average of that of the parents are named in their order as follows: Orinoco × Big Warne, 24.2; Samsoun Bafra × Orinoco, 22.2; Big Warne × Samsoun Bafra, 17.5; Conqueror × Orinoco, 11.2; Conqueror × Big Warne, 6.1; and Samsoun Bafra × Conqueror, 3.5 per cent.

Number of leaves.—Table 2 shows that the frequency of distribution of the number of leaves of the hybrids in most cases

FIG. 5. Leaves of F_1 plant—a cross between Orinoco and Big Warne; *a*, inflorescence leaf; *b*, middle standard leaf.

FIG. 6. Leaves of F_1 plant—a cross between Conqueror and Orinoco; *a*, inflorescence leaf; *b*, middle standard leaf.

are intermediate between the parents. The standard deviation of the parents and hybrids ranges from 1.14 ± 0.108 to 2.22 ± 0.236 and 1.24 ± 2.30 centimeters, respectively. The standard deviation seems to show that the hybrids are as uniform as the parents with respect to this character.

The crosses which produced the greatest number of leaves are Samsoun Bafra × Orinoco, 36.00 ± 0.338; Big Warne × Samsoun Bafra, 29.30 ± 0.297 and Samsoun Bafra × Conqueror, 27.70 ± 0.346.

Table 6 shows that in eight cases out of twelve the increase in the number of leaves in favor of the hybrids is significant, since the probable error of the difference is less than three times the mean difference. In three instances the number of leaves of one of the parents is greater than that of the hybrids. In these cases the number of leaves of the hybrids is only intermediate between that of the parents. In other words the hybrids excel only one of the parents. For instance, the cross Samsoun Bafra × Conqueror has a mean of 27.70 ± 0.346. On the other

FIG. 7. Typical leaves of the variety Big Warne; *a*, inflorescence leaf; *b*, middle standard leaf.

FIG. 8. Typical leaves of the variety Orinoco; *a*, inflorescence leaf; *b*, middle standard leaf.

hand Samsoun Bafra has a mean of 32.90 ± 0.334 and Conqueror, 22.42 ± 0.240.

The difference in number of leaves in favor of the hybrids ranges from 0.64 ± 0.408 to 11.18 ± 0.335. The crosses in which one of the parents has more number of leaves are Samsoun Bafra × Conqueror, Conqueror × Big Warne and Big Warne × Samsoun Bafra.

As may be seen in Table 8, with the exception of one case, the hybrids excel the average of the parents in the number of leaves. The increase ranges from 0.1 to 24 per cent. The number of leaves of the cross Conqueror × Big Warne is 0.9 per

cent less than the average number of leaves of the parents. The percentage of increase in number of leaves of the hybrids over the average of the parents is as follows: Samsoun Bafra × Conqueror, 0.1; Conqueror × Orinoco, 1.0; Big Warne × Samsoun Bafra, 14.8; Orinoco × Big Warne, 19.3 and Samsoun Bafra × Orinoco, 24.0.

Breadth index of leaves.—According to Table 3 only 50 per cent of the hybrids are intermediate between the parents for this

FIG. 9. Typical leaves of the variety Conqueror; *a*, inflorescence leaf; *b*, middle standard leaf.

FIG. 10. Typical leaves of the variety Samsoun Bafra; *a*, inflorescence leaf; *b*, middle standard leaf.

particular character. The rest of the hybrids have smaller breadth indices than either parent. Among the former is the variety Samsoun Bafra, which has the broadest leaves in one of the parents.

The crosses which produced the broadest leaves are the following: Samsoun Bafra × Conqueror and Big Warne × Samsoun Bafra with breadth indices of 51.40 ± 0.303 and 50.30 ± 0.712 per cent, respectively.

As regards their standard deviation the hybrids are generally lower than the parents except for the cross Big Warne × Samsoun Bafra, which has a standard deviation of 4.48 ± 0.503, the

highest so far. In the same way the hybrids have lower standard deviations than their parents, except in a few cases.

It will be observed in Table 6 that only three crosses excelled one of the parents in breadth index. The differences in all of them are significant. In the other nine crosses the difference is in favor of the parents, however, although significant only in six cases.

Only the following crosses excelled one of the parents in breadth index: Samsoun Bafra × Orinoco, Big Warne × Samsoun Bafra and Samsoun Bafra × Samsoun.

Table 9 shows that the percentage of increase in breadth index of the hybrids over the average of the parents are all negative. The difference ranges from 2.9 to 12.8 per cent. The percentage of increase in breadth index of the hybrids over the average of the parents in their order are as follows: Conqueror × Orinoco — 12.8, Orinoco × Big Warne — 11.8, Samsoun Bafra × Orinoco — 8.2, Conqueror × Big Warne, 4.5, Big Warne × Samsoun Bafra — 3.2 and Samsoun Bafra × Conqueror — 2.9 per cent.

Yield per hectare.—Table 4 shows that the average yield of the hybrids per hectare is intermediate between the parents in four cases, the hybrids excelling both parents in the other two cases. The coefficient of variability in the parents ranges from 14.28 ± 1.552 to 24.32 ± 4.896 and in the hybrids from 17.52 ± 1.757 to 26.17 ± 2.904 per cent. This shows that the parents are more uniform in this character than the hybrids.

The three crosses which produced the greatest yield per hectare are the following: Conqueror × Big Warne, 21.06 ± 0.691, Conqueror × Orinoco, 20.60 ± 0.497 and Orinoco × Big Warne, 20.24 ± 0.523 quintals.

Table 6 shows that in nine cases the yield of the hybrids is greater than that of their parents. The differences, however, are significant only in seven cases. In the other three cases the differences are in favor of the parents, but they are significant only in one.

The difference in yield in favor of the hybrids ranges from 1.36 ± 0.803 to 7.20 ± 0.441 quintals. On the other hand the difference in yield in favor of one of the parents ranges from 0.94 ± 0.876 to 3.60 ± 0.823 quintals.

Table 10 shows that in all cases the yield of the hybrids is greater than the average yield of the parents. The increase ranges from 3.4 to 26.5 per cent.

TABLE 1.—*Frequency distribution of height of plants of six F_1 tobacco hybrids and their parents*

Class centers	F_1 Hybrid					
	Samsoun Bafra × Conqueror	Conqueror × Big Warne	Big Warne × Samsoun Bafra	Samsoun Bafra × Orinoco	Orinoco × Big Warne	Conqueror × Orinoco
cms.						
55						
65						
75						
85						
95		1				
105		0				
115		0				
125		0				1
135		1			3	2
145	1	2		1	8	6
155	3	4	2	6	7	6
165	2	4	5	10	6	8
175	9	8	5	1	1	1
185	5	2	6	3		
195		1	2			
205			1			
Total	20	23	21	21	25	24
Mean	168.00±1.727	159.70±2.852	173.00±1.936	160.60±1.556	148.60±1.442	149.80±1.660
Standard deviation	11.45±1.221	20.28±2.016	13.15±1.369	10.57±1.100	10.69±1.019	12.06±1.17
Coefficient of variability	6.81± .726	12.69±1.282	7.60± .791	6.58± .685	7.19± .686	8.05± .783

Class centers	Parent			
	Big Warne	Orinoco	Conqueror	Samsoun Bafra
cms.				
55		2		
65		0		
75		1		
85	1	1		
95	0	2		
105	0	4		
115	2	8		
125	3	5		
135	5	2		
5	6		2	1
155	7		12	3
165	1		7	15
175			3	1
185				
195				
205				
Total	25	25	24	20
Mean	135.40±2.329	103.80±2.816	165.60±1.126	159.00±.904
Standard deviation	17.22±1.642	20.88±1.991	8.18± .796	6.00±.639
Coefficient of variability	12.71±1.237	20.11±1.993	4.94± .481	3.77±.402

TABLE 2.—*Frequency distribution of number of leaves of six F_1 tobacco hybrids and their parents*

Class centers	F_1 Hybrid					
	Samsoun Bafra × Conqueror	Conqueror × Big Warne	Big Warne × Samsoun Bafra	Samsoun Bafra × Orinoco	Orinoco × Big Warne	Conqueror × Orinoco
cms.						
16						
18		4				
20		14				
22		5				3
24	3				7	10
26	5				6	7
28	5		6		7	3
30	6		8		5	1
32	1		6	3		
34			0	3		
36			1	8		
38				5		
40				2		
Total	20	23	21	21	25	24
Mean	27.70±.346	20.08±.175	29.30±.297	36.00±.338	25.80±.294	24.10±.280
Standard deviation	2.30±.245	1.24±.124	2.01±.210	2.30±.239	2.18±.207	2.04±.199
Coefficient of variability	8.30±.885	6.21±.618	6.88±.716	6.38±.664	8.44±.805	8.46±.824

Class centers	Parent			
	Big Warne	Orinoco	Conqueror	Samsoun Bafra
cms.				
16	1			
18	9			
20	15		5	
22		1	11	
24		8	6	
26		6	2	
28		8		1
30		2		3
32				6
34				6
36				4
38				
40				
Total	25	25	24	20
Mean	18.12±.154	25.11±.284	22.42±.240	32.90±.334
Standard deviation	1.14±.108	2.11±.201	1.74±.169	2.22±.236
Coefficient of variability	6.30±.601	8.38±.799	7.76±.755	6.74±.718

TABLE 3.—*Frequency distribution of breadth index of the six F_1 tobacco hybrids and their parents*

Class centers	F_1 Hybrid					
	Samsoun Bafra × Conqueror	Conqueror × Big Warne	Big Warne × Samsoun Bafra	Samsoun Bafra × Orinoco	Orinoco × Big Warne	Conqueror × Orinoco
Per cent						
30					2	
32					0	
34					1	2
36					9	6
38					7	4
40		4	1	3	4	8
42		7	1	6	2	4
44		2	2	3		
46		3	0	4		
48	2	5	3	3		
50	7	2	5	1		
52	7		3	1		
54	3		2			
56	1		2			
58						
60						
62						
64						
66						
Total	20	23	21	21	25	24
Mean	51.40±.303	44.36±.469	50.30±.712	44.48±.488	37.04±.375	37.50±.338
Standard deviation	2.01±.214	3.33±.331	4.84±.503	3.32±.345	2.78±.265	2.46±.239
Coefficient of variability	3.91±.417	7.52±.748	9.62±1.001	7.46±.776	7.50±.716	6.56±.538

Class centers	Parent			
	Big Warne	Orinoco	Conqueror	Samson Bafra
Per cent				
30				
32		2		
34		3		
36		6		
38		4		
40	1	3	1	
42	6	3	1	
44	6	2	1	
46	4	1	3	
48	5	0	8	
50	1	1	4	
52	1		4	
54	1		2	1
56				3
58				5
60				6
62				3
64				1
66				1
Total	25	25	24	20
Mean	45.44±.455	38.56± .588	47.50±.462	58.40±.428
Standard deviation	3.37±.311	4.36± .416	3.36±.327	2.84±.303
Coefficient of variability	7.41±.707	11.31±1.090	7.07±.688	4.86±.518

TABLE 4.—*Frequency distribution of yield per hectare of six F_1 tobacco hybrids and their parents*

Class centers	F_1 Hybrid					
	Samsoun Bafra × Conqueror	Conqueror × Big Warne	Big Warne × Samsoun Bafra	Samsoun Bafra × Orinoco	Orinoco × Big Warne	Conqueror × Orinoco
quintals						
8						
10	1		2	1		
12	2		5	2		
14	2	4	1	5	2	2
16	2	2	5	6	3	4
18	1	3	2	3	7	1
20	6	2	3	0	3	4
22	5	2	1	2	3	6
24	0	5	2	2	3	5
26	1	2			3	2
28		2			1	
30		1				
Total	20	23	21	21	25	24
Mean	18.40 ± .623	21.06 ± .691	16.20 ± .624	16.48 ± .550	20.24 ± .523	20 60 ± .497
Standard deviation	4.13 ± .440	4.92 ± .489	4.24 ± .442	3.74 ± .389	3.88 ± .370	3.61 ± .351
Coefficient of variability	22.44 ± 2.453	23.36 ± 2.446	26.17 ± 2.904	22.69 ± 2.480	19.16 ± 1.893	17.52 ± 1.757

Class centers	Parent			
	Big Warne	Orinoco	Conqueror	Samsoun Bafra
quintals				
8				2
10	2			6
12	4	3		10
14	11	5		2
16	5	5	4	
18	2	1	1	
20	0	7	4	
22	1	0	7	
24		2	2	
26		1	3	
28		1	2	
30			1	
Total	25	25	24	20
Mean	14.40± .340	17.84± .585	22.00± .538	11.20± .241
Standard deviation	2.52± .240	4.34± .414	3.91± .381	1.60± .170
Coefficient of variability	17.50±1.720	24.32±4.895	17.77±1.784	14.28±1.553

TABLE 5.—*Frequency distribution of period of maturity of six F_1 tobacco hybrids and their parents*

Class centers	F_1 Hybrid					
	Samsoun Bafra × Conqueror	Conqueror × Big Warne	Big Warne × Samsoun Bafra	Samsoun Bafra × Orinico	Orinoco × Big Warne	Conqueror × Orinoco
days						
94	1					
96	4	1	3			
98	3	1	1			
100	3	2	2			
102	2	3	3			
104	4	8	4	3	2	
106	2	5	7	10	2	
108	1	3	1	5	3	5
110				3	3	8
112					4	5
114					6	3
116					5	2
118						1
120						
122						
124						
126						
128						
130						
132						
134						
136						
138						
140						
142						
Total	20	23	21	21	25	24
Mean	100.60±.596	103.74±.424	102.78±.541	106.78±.268	111.44±.509	111.34±.380
Standard deviation	3.95±.421	3.02±.300	3.68±.383	1.81±.189	3.77±.360	2.76±.268
Coefficient of variability	3.92±.419	2.91±.289	3.58±.373	1.70±.177	3.38±.322	2.47±.240

Class centers	Parent			
	Big Warne	Orinoco	Conqueror	Samsoun Bafra
days				
94				
96				
98				
100				
102				
104				
106				1
108				1
110				2
112				3
114				4
116	3			7
118	3		2	1
120	4		6	1
122	9		4	
124	4		7	
126	2		5	
128		1		
130		1		
132		1		
134		1		
136		6		
138		10		
140		2		
142		1		
		2		
Total	25	25	24	20
Mean	119.12±.382	135.20±.483	120.60±.352	111.80±.503
Standard deviation	2.83±2.70	3.58±.342	2.56±.249	3.34±.356
Coefficient of variability	2.37±2.27	2.64±.253	2.12±.207	2.98±.319

TABLE 6.—*Comparison between the F_1 hybrids and their parents in height of plants, number of leaves, breadth index, yield per hectare and period of maturity*

Variety name	Height of plants	Number of leaves	Breadth index	Yield per hectare	Period of maturity
	(cms.)		*per cent*	*quintals*	*days*
Samsoun Bafra × Conqueror	168.0±1.727	27.70±.346	51.40±.303	18.40±.623	100.60±.596
Conqueror	165.6±1.126	22.42±.240	47.50±.462	22.00±.538	120.60±.352
Difference	2.4±2.062	5.28±.411	3.90±.553	−3.60±.823	−20.40±.682
Samsoun Bafra × Conqueror	168.0±1.727	27.70±.346	51.40±.303	18.40±.623	100.60±.596
Samson Bafra	159.0± .904	32.90±.334	58.40±.428	11.20±.241	111.80±.503
Difference	9.0±1.949	−5.20±.480	7.00±.524	7.20±.441	11.20±.780
Conqueror × Big Warne	159.7±2.852	20.08±.175	44.36± 469	21.06± 691	103.74±.424
Big Warne	135.4±2.329	18.12±.154	45.44± 455	14.40±.340	119.12±.382
Difference	24.3±3.682	1.96±.233	−.08±.653	6.66±.770	−15.38±.571
Conqueror × Big Warne	159.7±2.852	20.08±.175	44.36±.469	21.06±.691	103.74±.424
Conqueror	165.6±1.126	22.42±.240	47.50±.462	22.00±.538	120.60±.352
Difference	−5.9±3.066	−2.34±.297	−3.14±.658	−0.94±.876	−16.86±.551
Big Warne × Samsoun Bafra	173.0±1.936	29.30±.297	50.30± .712	16.20±.624	102.78±.541
Samsoun Bafra	159.0± .904	32.90±.334	58.40±.428	11.20±.241	111.80±.503
Difference	14.0±2.138	−3.60±.447	−8.10±.831	5.00±.669	−9.02±.738
Big Warne × Samsoun Bafra	173.0±1.936	29.30±.297	50.30±.712	16.20±.624	102.78±.541
Big Warne	135.4±2.329	18.12±.154	45.44±.455	14.40±.340	119.12±.382
Difference	37.8±3.028	11.18±.335	4.86±.845	1.80±.711	−16.34±.662
Samsoun Bafra × Orinoco	160.6±1.556	36.00±.338	44.48±.488	16.48±.550	106.78±.268
Orinoco	103.8±2.816	25.16±.284	38.56±.588	17.84±.585	135.20±.483
Difference	56.8±3.117	10.84±.441	5.92±.764	−1.36±.803	−28.42±.552
Samsoun Bafra × Orinoco	160.6±1.556	36.00±.338	44.48±.488	16.48±.550	106.78±.268
Samsoun Bafra	159.0± .904	32.90±.334	58.40±.428	11.20±.241	111.80±.503
Difference	1.6±1.799	3.10±.475	−3.92±.649	5.28±.600	−5.02±.570

Orinoco × Big Warne	148.6±1.442	25.80±.294	37.04±.375	20.24±.523	111.44±.509
Big Warne	135.4±2.329	18.12±.154	45.44±.455	14.40±.340	119.12±.382
Difference	13.2±2.739	7.68±.332	−8.40±.589	5.84±.624	−7.68±.636
Orinoco × Big Warne	148.6±1.442	25.80±.294	37.04±.375	20.24±.523	111.44±.509
Orinoco	103.8±2.816	25.16±.284	38.56±.588	17.84±.585	135.20±.483
Difference	44.8±3.164	.64±.408	−1.52±.697	2.40±.785	−23.76±.702
Conqueror × Orinoco	149.8±1.660	24.10±.280	37.50±.338	20.60±.497	111.34±.380
Orinoco	103.8±2.816	25.16±.284	38.56±.588	17.84±.585	135.20±.483
Difference	46.0±3.269	1.06±.398	1.06±.678	2.76±.768	−23.86±.615
Conqueror × Orinoco	149.8±1.660	24.10±.280	37.50±.338	20.60±.497	111.34±.380
Conqueror	165.6±1.126	22.42±.240	47.50±.462	22.00±.538	120.60±.352
Difference	15.8±2.005	1.68±.369	−10.00±.572	1.40±.732	−9.26±.518

TABLE 7.—*Height of six F_1 tobacco hybrids compared with parents*

Hybrid	Height of female parent	Height of male parent	Average height of parents	Height of hybrids	Percentage of increase of hybrid over average of parents
	cms.	*cms.*	*cms.*	*cms.*	*per cent*
Samsoun Bafra × Conqueror	159.00	165.60	162.30	168.00	3.5
Conqueror × Big Warne	165.60	135.40	150.50	159.70	6.1
Big Warne × Samsoun Bafra	135.40	159.00	147.20	173.00	17.5
Samsoun Bafra × Orinoco	159.00	103.80	131.40	160.60	22.2
Orinoco × Big Warne	103.80	135.40	119.60	148.60	24.2
Conqueror × Orinoco	165.60	103.80	134.70	149.80	11.2

TABLE 8.—*Number of leaves of six F_1 tobacco hybrids compared with parents*

Hybrid	Number of leaves of female parent	Number of leaves of male parent	Average number of leaves of parent	Number of leaves of hybrids	Percentage of increase of hybrid over average of parents
					per cent
Samsoun Bafra × Conqueror	32.90	22.42	27.66	27.70	0.1
Conqueror × Big Warne	22.42	18.12	20.27	20.08	—0.9
Big Warne × Samsoun Bafra	18.12	32.90	25.51	29.30	14.8
Samsoun Bafra × Orinoco	32.90	25.11	29.01	36.00	24.0
Orinoco × Big Warne	25.11	18.12	21.61	25.80	19.3
Conqueror × Orinoco	22.42	25.11	23.76	24.10	1.0

TABLE 9.—*Breadth index of six F_1 tobacco hybrids compared with parents*

Hybrid	Breadth index of female parent	Breadth index of male parent	Average breadth index of parent	Breadth index of hybrid	Percentage of increase of hybrid over average of parents
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Samsoun Bafra × Conqueror	58.40	47.50	52.95	51.40	— 2.9
Conqueror × Big Warne	47.50	45.44	46.47	44.36	— 4.5
Big Warne × Samsoun Bafra	45.44	58.40	51.97	50.30	— 3.2
Samsoun Bafra × Orinoco	58.40	38.56	48.48	44.48	— 8.2
Orinoco × Big Warne	38.56	45.44	42.00	37.04	—11.8
Conqueror × Orinoco	47.50	38.56	43.03	37.50	—12.8

The percentage of increase of the hybrids over the average of the parents in their order are as follows: Big Warne × Samsoun Bafra, 26.5; Orinoco × Big Warne, 25.5; Conqueror × Big Warne, 15.7; Samsoun Bafra × Orinoco, 13.4; Samsoun Bafra × Conqueror, 10.8; and Conqueror × Orinoco, 3.4 per cent.

Period of maturity.—Of all the characters studied the period of maturity presents the most interesting results. A glance at

Table 5 shows that without exception every one of the hybrids has a much shorter period of maturity than either parent. As regards their standard deviation, the parents and the hybrids are practically identical. From the coefficient of variability as basis of comparison, it can be concluded that both parents and hybrids are quite uniform in this particular character.

TABLE 10.—*Yield of six F_1 tobacco hybrids compared with parents*

Hybrid	Yield of female parent	Yield of male parent	Average yield of parents	Yield of hybrid	Percentage of increase of hybrid over average of parents
	quintals	*quintals*	*quintals*	*quintals*	*per cent*
Samsoun Bafra × Conqueror	11.20	22.00	16.60	18.40	10.8
Conqueror × Big Warne	22.00	14.40	18.20	21.06	15.7
Big Warne × Samsoun Bafra	14.40	11.20	12.80	16.20	26.5
Samsoun Bafra × Orinoco	11.20	17.84	14.52	16.48	13.4
Orinoco × Big Warne	17.84	14.40	16.12	20.24	25.5
Conqueror × Orinoco	22.00	17.84	19.92	20.60	3.4

TABLE 11.—*Period of maturity of six F_1 tobacco hybrids compared with parents*

Hybrid	Period of maturity of female parent	Period of maturity of male parent	Average period of maturity of parents	Period of maturity of hybrid	Percentage of increase of hybrid over average of parents
	days	*days*	*days*	*days*	*per cent*
Samsoun Bafra × Conqueror	113.80	120.60	117.20	100.60	—14.1
Conqueror × Big Warne	120.60	119.12	119.86	103.74	—13.4
Big Warne × Samsoun Bafra	119.12	113.80	116.46	102.78	—11.7
Samsoun Bafra × Orinoco	113.80	135.20	124.50	106.78	—14.2
Orinoco × Big Warne	135.20	119.12	127.16	111.44	—12.3
Conqueror × Orinoco	120.60	135.20	127.90	111.34	—12.9

The hybrids which matured at a much shorter period are the following: Samsoun Bafra × Conqueror, 100.60 ± 0.596; Big Warne × Samsoun Bafra, 102.78 ± 0.541 and Conqueror × Big Warne, 103.74 ± 0.424 days.

The comparison of the hybrids with their parents in Table 6 shows that the differences in period of maturity are all in favor of the hybrids. The mean difference ranges from — 5.02 ± 0.570 to — 28.42 ± 0.552 days.

The difference in period of maturity in favor of the hybrids ranges from 5.02 ± 0.570 to 28.42 ± 0.552 days.

Table 11, where the differences in period of maturity are expressed in percentage, shows that the difference in favor of the hybrids over the average of the parents ranges from 11.7 to 14.2 per cent.

The percentages of increase of the hybrids over the averages of the parents are as follows: Samsoun Bafra × Orinoco — 14.2; Samsoun Bafra × Conqueror, — 14.1; Conqueror × Big Warne, — 13.4; Conqueror × Orinoco, 12.9; Orinoco × Big Warne, 12.3; and Big Warne × Samsoun Bafra, 11.7 per cent.

SUMMARY AND CONCLUSIONS

1. Hybrid vigor or heterosis was generally manifested in the first filial generation hybrids for all the characters studied except for the breadth index of leaves.

2. Of the six hybrids studied, the F_1 plants were taller than either parent in four cases, and in two cases the hybrids were intermediate between the parents, but the tendency was to approach the taller parent. These results agree with those previously obtained by Howard (1913) in the case of the Indian types of tobacco but differ from those obtained by Hayes (1912) with *N. tabacum* where the F_1 generation was generally intermediate in height with a leaning towards the taller parent.

3. In the number of leaves per plant, four of the hybrids were intermediate between the two parents, and the other two excelled both parents.

4. For breadth index of the leaves the hybrids in three cases were intermediate between the parents, the rest of the hybrids being inferior to both parents.

5. Four of the hybrids were intermediate between the parents in yield while two had a larger yield than both parents.

6. In all cases the time of flowering or the period of maturity of the hybrids was much shorter than either parent. These results do not conform to those observed by Howard in *N. tabacum* and *N. rustica* where the F_1 was intermediate between the parents.

7. Except for breadth index of leaves, the hybrids had a greater mean than the average of the parents for all the characters studied. The percentage of increase of the hybrids over the average of the parents follows: height of plant, ranging from 3.5 to 24; number of leaves per plant, 0.1 to 24; yield per hectare, 3.4 to 26.5 and period of maturity, 11.7 to 14.2 per cent.

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8. The results of these experiments show that trial planting of the first filial generation hybrids of cigarette tobacco can be recommended.

9. For best results, it is recommended that the parents to be crossed must be of superior varieties and possess identical or nearly identical characters.

10. Fresh stock of pure seeds of the parents must be on hand all the time.

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ILLUSTRATIONS

Plate 1

Fig. 1. F_1 plant of cross between Samsoun Bafra and Conqueror. Note the dominance of the leaf characters of Samsoun Bafra. The plant has an average height of 168 centimeters and an average number of 27 leaves.

2. F_1 plant of cross between Conqueror and Big Warne. The plant has an average height of 159 centimeters and an average number of 20 leaves.

Plate 2

Fig. 1. F_1 plant of cross between Big Warne and Samsoun Bafra. Note the dominance of the leaf characters of Samsoun Bafra. The plant has an average height of 173 centimeters and an average number of 29 leaves.

2. F_1 plant of cross between Samsoun Bafra and Orinoco. Note the dominance of the leaf characters of Samsoun Bafra. The plant has an average height of 160 centimeters and an average number of 36 leaves.

Plate 3

Fig. 1. F_1 plant of cross between Orinoco and Big Warne. Note the dominance of Orinoco. The plant has an average height of 148 centimeters and an average number of 25 leaves.

2. F_1 plant of cross between Conqueror and Orinoco. Note the dominance of the leaf characters of Orinoco. The plant has an average height of 149 centimeters and an average number of 24 leaves.

Plate 4

Fig. 1. A typical plant of the variety Big Warne. The plant has an average height of 135 centimeters and an average number of 18 leaves.

2. A typical plant of the variety Orinoco. The plant has an average height of 103 centimeters and an average number of 25 leaves.

Plate 5

Fig. 1. A typical plant of the variety Conqueror. The plant has an average height of 164 centimeters and an average number of 22 leaves.

2. A typical plant of the variety Samsoun Bafra. The plant has an average height of 159 centimeters and an average number of 32 leaves.

TEXT FIGURES

FIG. 1. Leaves of F_1 plant—a cross between Samsoun Bafra and Conqueror; *a*, inflorescence leaf; *b*, middle standard leaf.
2. Leaves of F_1 plant—a cross between Conqueror and Big Warne; *a*, inflorescence leaf; *b*, middle standard leaf.
3. Leaves of F_1 plant—a cross between Big Warne and Samsoun Bafra; *a*, inflorescence leaf; *b*, middle standard leaf.
4. Leaves of F_1 plant—a cross between Samsoun Bafra and Orinoco; *a*, inflorescence leaf; *b*, middle standard leaf.
5. Leaves of F_1 plant—a cross between Orinoco and Big Warne; *a*, inflorescence leaf; *b*, middle standard leaf.
6. Leaves of F_1 plant—a cross between Conqueror and Orinoco; *a*, inflorescence leaf; *b*, middle standard leaf.
7. Typical leaves of variety Big Warne; *a*, inflorescence leaf; *b*, middle standard leaf.
8. Typical leaves of the variety Orinoco; *a*, inflorescence leaf; *b*, middle standard leaf.
9. Typical leaves of the variety Conqueror; *a*, inflorescence leaf; *b*, middle standard leaf.
10. Typical leaves of the variety of Samsoun Bafra; *a*, inflorescence leaf; *b*, middle standard leaf.

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PLATE 1.

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PLATE 2.

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PLATE 3.

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PLATE 4.

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PLATE 5.

PROGRESS REPORT ON THE GREEN-LEAF SPOT OF PHILIPPINE WRAPPER LEAF TOBACCO

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ONE PLATE AND THREE TEXT FIGURES

There are at present several spot diseases of leaf tobacco reported and studied in practically all the tobacco-producing countries of the world. Among the most common are the blight, frog eye, wild fire, angular leaf spot, leaf scald, red rust, brown rust, black fire, specks and the so-called "batek" which is prevalent in La Union and Pangasinan. Most leaf spot maladies are either due to fungus or bacterial organisms, and a few are caused by mal-nutrition or other physiological and mechanical disturbances. Not so long ago, a new spot disease appeared in the wrapper tobacco districts of the Philippines, doing severe damage to both open and shade-grown wrappers. This spot malady is commonly termed the green leaf spot.

1. PREVIOUS LITERATURE ON THE SUBJECT

Gutierrez,(3) while conducting wrapper tobacco investigations in the defunct Pikit and Sarunayan Tobacco Stations in Cotabato, Mindanao, had always complained of the frequent appearance of what he termed, "fungus leaf spots," which were colored green. The occurrence of this so-called fungus leaf spot had been one of the principal difficulties in wrapper production in the Cotabato Valley which led ultimately to the closing of the Sarunayan station in 1928 after functioning for a period of nine years.

According to Gutierrez, the appearance of the fungus leaf spot at Sarunayan station was always associated with damp weather specially when rain and showers were frequent during harvest season. It may be stated in this connection that the Cotabato Valley has quite an even distribution of rainfall throughout the year.

2. CHARACTERISTICS OF GREEN LEAF SPOT

Because of its characteristic green color, this spot malady is commonly termed "green leaf spot." The spot is always almost circular, brittle in texture, somewhat thickened, and rough to the touch. The spot is never apparent in the field. Neither do fresh, newly strung leaves show any sign of green spotting. The leaf spot manifests itself only when the curing leaves begin to dry, that is, when the wilting stage is about to terminate and the yellowing stage emerges. It can be easily suspected as a malady acquired in the curing barn. Leaves with green leaf spot cure rather irregularly, the spotted portion drying very much earlier and faster than the rest of the leaf. After a thorough fermentation, the green spot becomes light-colored, and in mild cases, almost obscured upon aging.

3. FIELD OBSERVATIONS

The writers first observed the green leaf spot from a shade-grown 1931–1932 wrapper crop produced in the Tubao Valley and in the provincial tobacco project at Bangar, La Union. From then up to the present time it has been observed in practically all the wrapper districts of the country affecting shade-grown wrapper leaf tobacco in Laguna and La Union, and open-grown wrapper leaf tobacco produced at the Davao Penal Colony in Mindanao. To get a better knowledge and understanding of the green leaf spot, the following field observations and laboratory studies done by the authors are hereby presented, beginning from the 1931–1932 season up to that of 1934–1935 which is just over.

1931–1932 SEASON

(*a*) *Tubao, La Union Project.*—Tubao Valley is the best region in the entire Ilocos Provinces for the production of cigar filler, cigar wrapper, and batek leaf tobacco. It is an interior district with quite a high elevation and surrounded by mountain ranges with the Aringay River meandering through it. Mount Sto. Tomas of Baguio, Mountain Province, overlooks the valley

from the south. The first shading experiment in La Union was conducted in this valley during this season in a field owned and operated by coöperator Rufino Gagni of barrio Garcia, municipality of Tubao. This particular field, like the rest of the Tubao Valley, is severely infected with a certain tobacco wilt disease which up to the present time since 1928 has been doing considerable damage to the tobacco crop of the province. It may be stated in this connection that within the last two seasons (1929–1930 and 1930–1931), fertilizer experiments had been conducted in this field by the Bureau of Plant Industry with the aim of finding a remedy for the control of the tobacco wilt disease. As no significant result was obtained upon the application of fertilizer to control wilt disease, shading was tried; first, as a last attempt to control wilt disease; and second, to produce a wrapper crop.

The area of the experimental field was about a hectare but only a small portion of it was shaded containing about a thousand plants. The whole area was planted to the *Simmaba* variety, the greater portion of the plantation being devoted to batek and cigar filler leaf tobacco production. Transplanting was done early in November and the shelter tent subsequently erected about the middle of January. There was an intense dry weather, hence, it was necessary to water the shaded plants twice at four days interval. The first watering was applied just after the shade was completed. The shaded plants grew exceedingly robust and while some plants showed signs of wilt attack before shading, they recovered several days after they had been shaded.

The appearance of the green leaf spot was first noticed when the first and second harvests from the shaded plants were undergoing the curing process. As the curing stage advanced, small circular spots with deep green color were noted scattered on the lamina, drying in a very much faster rate than the remaining portion of the leaf. It was at first suspected that the spotting was acquired in the curing barn. The interior and surroundings of the shade were therefore thoroughly cleaned and more adequate ventilations were provided. In spite of all these precautions the green spot continued its appearance on the third harvest. Attention was focussed to the field but no indication of occurrence of the disease was noticeable either in the shaded or in the open culture. It was later suspected that the green leaf spot came about as a result of watering the plants during their early stage under the shade. The severity of the green leaf spot was

much less in the fourth and fifth harvest until it was entirely absent in the last four primings. It should be mentioned here that the gradual disappearance of the spot followed the trend of the increasing dry season. Crops harvested during the height of the dry season were free from green leaf spots.

(*b*) *La Union Provincial Project, Bangar, La Union.*—Green leaf spot also occurred in the shade-grown tobacco project at the provincial nursery in Bangar, but absent in the open culture. The conditions surrounding both the Bangar and Tubao projects were identical; hence, we were led to believe that the green leaf spot must be a field disturbance brought about by excessive moisture owing to irrigation and greatly aggravated by the modified environment as a result of the shading. The liberal application of water to the shaded plantation was stopped although the plants at their early stage were in great need of water for lack of rain. The spottings, however, did not disappear until after the driest part of the harvesting season, when the green spot became less and less until it was nearly absent on the last three primings.

1932–1933 SEASON

(*a*) *Tubao, La Union Project.*—The same field was used during this season; but instead of shading only a portion of the field, the whole area was shaded. Our coöperator was encouraged to shade the whole area as a result of good price obtained on the first crop. Planting distances were made closer to accommodate more plants per unit area of the shaded ground inasmuch as the field was fertile. The weather condition at transplanting time (November) was very favorable so the entire field was planted before the fifteenth of November. The tent cover was placed more sparsely. As the season advanced, the wilt disease was watched for its appearance, but it was evident that if any plant died of wilt the number was very negligible. It was, therefore, considered that the wilt disease was already under control. At the early growing period, there had been frequent rains which favored the rapid and vigorous growth of the plants. Judging from the stand of the crop in the field, an excellent harvest was anticipated. The lower sand leaves were harvested on January 3 and drying began after 7 days. The expectation for a good crop was a disappointment. The leaves were so severely spotted that the crop was entirely discarded. Thinning the tent shade was resorted to. Harvesting was purposely stopped and all leaves that were over-matured

were picked and cured as filler tobacco. Harvesting was resumed when there was no rain. The lower leaves still bore the green spots but not as abundant as those of the sand leaves. Green spots became less numerous but not entirely eliminated. The succeeding harvests, done as the dry season advanced, bore less and less green spots until the last primings were free from disease.

(*b*) *La Union Provincial Project, Bangar, La Union.*—The November planting in this project was the Sumatra variety. The early apperance of frenching and mosaic diseases rendered the first planting unsuitable for shade culture. The December and January plantings were of the *Simmaba* variety and were shaded during the month of February and during the early days of March. The green spot was always present on the first three primings but always gradually disappearing in successive primings as long as no rain occurred at harvest season. The principal factor considered most responsible for the occurrence of the green spot in Bangar was the liberal application of irrigation water to the plants.

1933–1934 SEASON

(*a*) *Tubao, La Union Project.*—The area devoted to shade culture during the season under review was increased to five hectares by absorbing the nearest adjoining areas of the original experimental field. The weather condition was normal during the months of November and December but an unusually heavy rains occurred during the months of February and March. Although the stand of the plants was excellent, the quality and quantity of the crop was poor. Of the 56 quintals that would have been all fine wrappers only 27 quintals were accepted by the buying firms. The earlier harvests always bore plenty of green spots, but as priming advanced, accompanied by a dry weather, there was also a noteworthy diminution of the green spots until finally the last four primings were spotless.

(*b*) *La Union Provincial Project, Bangar, La Union.*—This season's observation of the green leaf spot at the provincial project was simply the repetition of the previous year's finding, confirming what was already noticed previously, but with adverse conditoins aggravated. The October planting besides being green spotted was gummiless. The latter plantings were of better quality but the green spot was always present in a varying degree. The late harvests were always free from green spots.

(*c*) *Hacienda Mercedes Project, Rosario, La Union.*—The wrapper project of this hacienda which was also started by the writers during the season under review was also observed because it represented another type of region in La Union where wrapper tobacco could be grown. The topography of the field is from undulating to hilly; hence only the small ravines are suitable for tobacco and rice culture. Its elevation is higher than that of Tubao although only 8 kilometers from the latter. This hacienda has a peculiar climate during the months of September, October, and November. There is a heavy rainfall which in most cases delays seeding and preparation of the tobacco fields. When the rainy season stops and tobacco is already set in the field there is much difficulty in watering the plants.

The wilt disease which was severe in the lowland was practically absent in the hacienda. This may be due to the fact that the land devoted to tobacco had been planted to tobacco in the past. During this season, the green leaf spot was not observed.

(*d*) *Los Baños Economic Garden Project.*—The first shading experiment in the Los Baños Economic Garden was conducted during this season, abacá cloth being used as shade. Three varieties, Ilagan Sumatra, Vizcaya, and Simmaba were used in this experiment, covering an area of one hectare. Each variety covered one-third of the whole area but replicated alternately ten times, one variety after another.

The soil is a sandy loam, quite stony and shallow. Transplanting was started late in November and terminated about the middle of December. There had been frequent rains and showers throughout the growing and harvesting seasons. At the early stage of the plants, a certain kind of wilt disease broke out which practically wiped out the Sumatra variety. The native varieties (Vizcaya and Simmaba) showed some degree of resistance against the wilt disease. Because of the frequent rains and showers throughout the growing period, the plants that escaped the ravages of the wilt grew very vigorously. The leaves, excepting a few that were affected by the mossaic disease, were clean and very green without any sign of unhealthiness.

The green leaf spot showed up on the first harvest in the shade culture, but not in the open culture. The few Ilagan Sumatra plants that survived the wilt were not severely affected by it. The green leaf spot on this project more than convinced the authors that this malady of wrapper leaf tobacco prevails over varying regions and climatic conditions, and may be considered one of the most serious maladies of locally grown wrapper.

1934–1935 SEASON

(*a*) *Tubao, La Union Project.*—During this season, the dry weather commenced early. Transplanting was greatly delayed for lack of seedlings. What seedlings there were on hand were stunted because of lack of rain. With this as an aggravating circumstance, this project, covering an area of about two hectares, was greatly affected. The shaded plants (late December planting) was so poor that even the standard leaves hardly reached 16 inches in length. There was absolutely no rain from the setting of the plants in the field up to the end of the season. An average of only eight leaves was harvested as wrapper leaves from every plant. Notwithstanding this poor stand in the field, the little crop obtained was the best in quality ever grown in the Tubao Valley. The leaves, though quite small in size, were very fine, elastic, light colored, silky, and free from any unsoundness. This crop which was about 12 quintals was recently appraised by the La Alhambra Cigar Factory at prices ranging from ₱2.50 to ₱3.50 a kilo.

(*b*) *La Union Provincial Project, Bangar, La Union.*—This project was temporarily discontinued this season because of lack of provincial appropriation.

(*c*) *Hacienda Mercedes Project, Rosario, La Union.*—This project, like that of Tubao, suffered a great deal from the dry weather that commenced early. Transplanting was started very late for lack of seedlings. The Hacienda was forced to buy seedlings from the farmers as their own seedlings were not fit for transplanting. Most of the fields were planted during the months of January and February. The management was forced to do patch shading and it was a common sight to see several small shaded areas in a big tobacco field scattered here and there. The crop, however, though meager in quantity was of very excellent quality, like that of Tubao. During the latter part of April it rained twice though sparingly, giving the stunted plants a chance to grow further, thereby increasing the production a great deal. The harvest after the rain, however, was green spotted but not severely.

(*d*) *Los Baños Economic Garden Project.*—The successive storms that visited the Islands from August to November seriously delayed the work on this project. The old field near the Radio Station was completely destroyed by floods, covering it with stones and gravel. It was, therefore, imperative to transfer the site of the project to the Economic Garden Proper up the hill.

The soil of the Economic Garden proper is heavier than that near the Radio Station below. Transplanting was done during the latter half of December and shading was completed about the first week of February. The same three varieties (Ilagan Sumatra, Vizcaya, and Simmaba) were again tried this season. There was just sufficient rain to give the newly transplanted seedlings a good start and to allow them to recover readily. When the plants were about a foot high, there was practically no more rain. The shade tent was nine feet high instead of six feet which was the height used during the last season. The curing barn had a galvanized-iron roofing and cement flooring but with abacá cloth as wall. The crop produced was of fine quality, free from spots of any kind, thin, glossy and light-colored. The standard leaves of the Simmaba and the Vizcaya varieties averaged sixty centimeters long. A more complete data on weather conditions were obtained and are presented in Tables 2, 3, 4, 5, and 6.

(*e*) *Davao Penal Colony Project.*—This project was started during the season under review by the Penal Colony with the aid of our Bureau men. The open-grown method of growing wrapper tobacco was practiced here in view of the mild weather condition of the locality. Like the Cotabato Valley, the Penal Colony has an almost even distribution of rainfall t[illegible]out the year. Although the plants were grown without sha[illegible], the leaves were thin and of fine quality as wrappers were it not for the presence of green leaf spot. The occurrence of this spot malady in Davao strengthens our contention that the "Fungus leaf spot" described by Gutierrez in Cotabato is the same as the green leaf spot which occurred in Davao. It is further claimed that this malady is brought about as a result of very moist weather during the harvesting season.

4. INTERPRETATION OF OBSERVED WEATHER FACTORS AT THE LOS BAÑOS ECONOMIC GARDEN IN RELATION TO THE PREVALENCE OF GREEN LEAF SPOT

1933–1934 SEASON

Due to lack of necessary apparatus needed in order to take a more complete data on weather factors, only the relative humidity, soil and air temperatures were observed during the months of February and March and are here presented in Table 1 and graphed as shown in Figure 1. The data here presented were obtained during the harvesting period.

Air temperature.—There was an average air temperature of 27.15 and 24.67 degrees centigrade in the open and in the shade cultures, respectively, during a period of 40 days of observation. It is interesting to note (Fig. 1) that the air temperatures both in the open and shade culture, during the harvesting season were quite irregular and fluctuating instead of either gradually rising or falling. The shade culture had an average of 2.48° C. lower

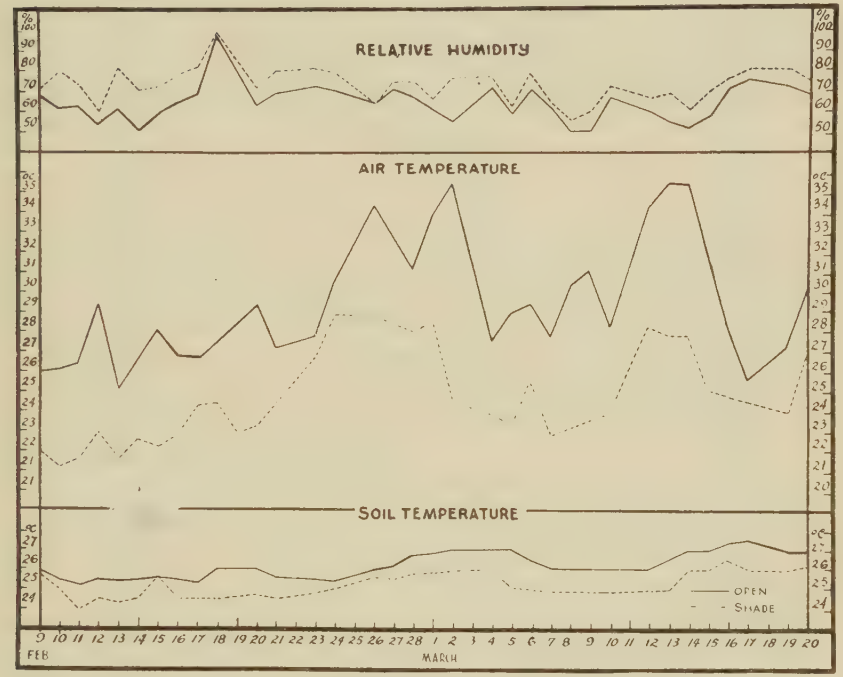

Fig. 1. Graph of weather records observed at Los Baños Economic Garden when green-leaf spot was rampant.

than that of the open culture during the 40 days of observation. The tent shade was only about six feet high, which was quite low in comparison with the standard height of tent shade which is nine feet.

Soil temperature.—The temperature of the soil in the open culture was always higher than that of the soil in the shade culture. There was noticed, however, no apparent rise of soil temperature as the harvesting season advanced which simply means that during the entire harvesting period the weather condition was characterized by frequent rains and showers.

Relative humidity.—The relative humidity of the air in the shade was higher than that of the air in the open, the average daily difference during a period of 40 days being 2.28 per cent. The relative humidity of the atmosphere both in the shade and in the open cultures was variable and very fluctuating instead

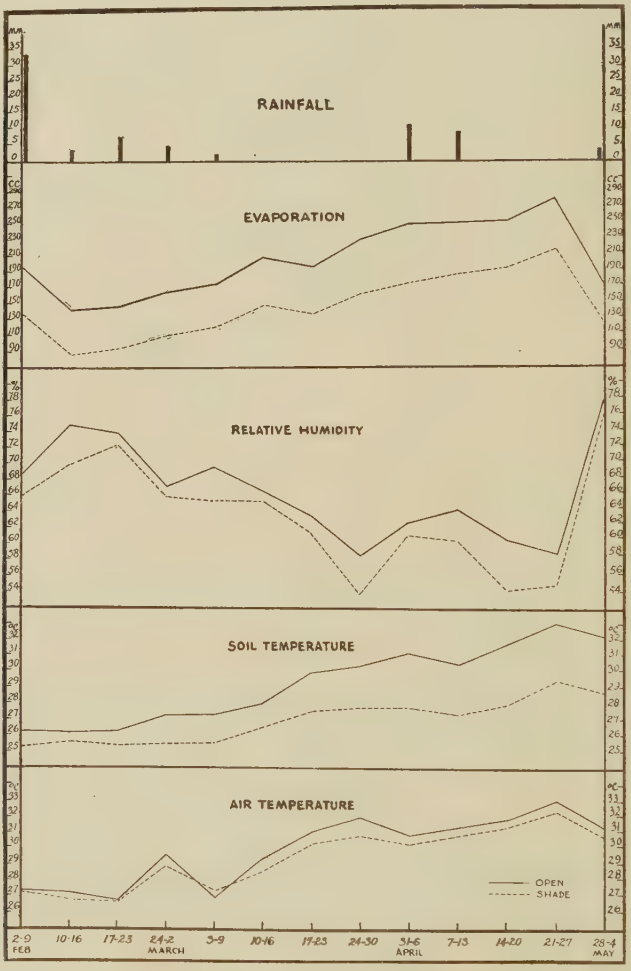

FIG. 2. Graph of weather records observed at Los Baños Economic Garden when green-leaf spot was practically absent.

of following a gradual trend in one direction which shows that the anticipated advance of dry season did not occur as usual but the humid weather remained unchanged throughout the harvesting period.

Prevalence of green spot. The shaded crop obtained at the Los Baños Economic Garden during this season was severely affected by green-leaf spot while that from the open was not. It is obvious, therefore, that the weather conditions which prevailed during this season were conducive to the appearance of the green-leaf spot on the shaded plantation. The weather condition particularly during the harvesting period was characterized with high relative humidity, low air and soil temperatures, and rains and showers were frequent throughout the growing and harvesting periods. Be it said that the tent shade was six feet high, which accounts for the much higher relative humidity in the shade than in the open culture.

1934–1935 SEASON

More complete data on weather factors were observed at the Los Baños Economic Garden during this season under review than during the preceding season. These data were gathered from February 2, when the shade tent was completed up to May 4, when the last harvest was made. The weather factors observed were (1) air and soil temperatures, (2) relative humidity, (3) evaporation, and (4) rainfall. The data gathered are graphed as shown in Fig. 2.

Air temperature.—The average day air temperature during a period of 92 days was 29.8° C. in the open and 29.3° C. in the shade (Table 2). Under both conditions (open and shade cultures) it is to be noted (Fig. 2) that there was a steady increase in air temperature starting from a low temperature to as high as 32.9° C. (Table 2). Low air temperature prevailed from February 2 to March 2, during the vegetative stage of the tobacco plant, and with high air temperature at the time of harvesting (Fig. 2).

Soil temperature.—The trend of the graphs of soil temperature both in the open and shade shows a very apparent steady rise of temperature from February 4 to May 4. The temperature of the soil in the shade tent, however, was always lower than the soil temperature in the open. There was a total difference of 2.4° C. although the weekly differences were much more apparent. Low soil temperature prevailed during the first month of growth and relatively high soil temperature existed during the latter part of the life of the tobacco plant (Fig. 2).

Relative humidity.—The trend of the graphs of relative humidity was just the reverse of the trend of the graph of air and soil temperatures (Fig. 2). The relative humidity of the air in the shade ranged from 58.8 to 78.7 per cent. In the exposed plots the relative humidity of the air varied from 52.2 to 77.1 per cent. There was, however, a total average difference of 3.1 per cent. Again the air was driest during the harvesting period.

Evaporation.—The evaporating power of the air was measured with the use of Livingston's white spherical atmometers. The rapidity of the water vapor to leave the wall of the atmometer is in direct proportion to the dryness of air immediately surrounding it; hence, the drier the atmosphere is, the faster is the rate of evaporation. The graphs of evaporation (Fig. 2) show that the evaporating power of the air in the shade was lower than that of the exposed air and that the factors favoring rapid evaporation were lowest during the first month when the tobacco plants were at their vegetative growth and highest during the remaining two months when the tobacco plants were maturing.

Rainfall.—There was a total of 76.45 mm. of rain that fell from February 2 to May 4 (Table 6). It is interesting to note that it rained nine times totaling 49.02 mm. during the month of February. After this month it rained once in March (2.54 mm.) and three times in April (Table 6). Fifty-five per cent of the total rainfall fell during the first month of growth and it rained only four times during the maturing and harvesting season (March and April). There were frequent rains during the vegetative stage of the tobacco plant and practically no rain during harvesting time; hence, there was a distinct wet and dry weather during the 1934–1935 tobacco season.

Prevalence of green-leaf spot.—There was practically no green spot in the 1934–1935 crop. This season's crop was characterized as having a distinct wet and dry season. Rain was frequent during the month of January and February (Table 6), the period when the tobacco plants were at their vegetative stage. It rained once during March, when the plants were maturing, and three times more during April, when the standard leaves were being harvested. Relative humidity was low especially during the harvesting season. It is evident, therefore, that, when a set of weather factors, such as high air and soil temperatures, low relative humidity, high evaporating power of the air (high evaporation) and rainless days prevail during the maturing

stage and the harvesting time, green leaf spot is practically absent but reverse weather conditions are favorable for the occurrence of green leaf spot as was observed in the 1933–1934 crop.

5. LABORATORY STUDY OF GREEN LEAF SPOT

1933–1934 CROP

1. *Qualitative test for starch content.*—Newly cured leaves both from the spotless open-grown and spotted shaded crop were boiled in water for 5 minutes and later soaked in 95 per cent alcohol to decolorize and finally washed thoroughly with cold water. The leaves were mounted on glass plates and finally treated with iodine solution.

Result: The spotless open-grown and the non-spotted portion of spotted shaded leaves were colored light brown with iodine while the green spotted portion of the shaded leaves turned dark blue; hence, starch was absent in the former and present in the latter.

2. *Qualitative test for chlorophyll content.*—Two grams each of the newly cured leaves from the (1) spotless open-grown, (2) spotless portion of green spotted shaded leaves, and (3) spotted sections of the shaded leaves were each soaked and heated in 30 cc. of 95 per cent alcohol in separate flasks to extract the chlorophyll. After extraction the chlorophyll-alcoholic extract solutions were each transferred into separate test tubes and allowed to cool. Later, 10 cc. of ether was added to each of the three solutions and shaken vigorously and finally allowed to settle.

Result: The lower layer of the ether-alcohol extracts obtained from the spotless open-grown leaves and from the healthy portions of the spotted shaded leaves was colored light green while the upper layer was light yellow. On the other hand, the lower layer of the ether-alcohol extract obtained from the green spotted sections of the shaded leaves showed a very deep green color and the upper layer a strong yellow color. There was, therefore, trace of chlorophyll in the former and abundant in the green spotted portions.

3. *Quantitative analysis for starch and chlorophyll contents.*—This test was conducted after the crop had long been fermented and aged for about a year. Sufficient samples of green spots and the spotless portions of the shaded leaves were analyzed for chlorophyll and starch contents.[1]

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[1] Analyzed by the Agricultural Chemistry Section, Bureau of Plant Industry.

Result: One year old green spotted shaded crop contained 2.13 per cent starch and the spotless portions, 5.32. Spotted sections contained an abundance of chlorophyll and only trace in the healthy ones.

4. *Anatomical structures of the leaves.*—Microscopic examinations of the leaf structure of (*a*) spotless open-grown leaves, (*b*) healthy portions of shaded leaves, and (*c*) green spotted sections of shaded leaves reveal the following:

Results:

1. Epidermal cells of open-grown leaves were short but broad with thick, regular, and smooth lateral walls. Epidermal cells of shaded leaves were long but narrow with thin, wavy or constricted walls.

2. Shaded leaves were amply provided with air spaces and palisade cells not developed. Open-grown leaves had few air spaces and well developed palisade cells.

3. No differences were noted between the cell structures of the healthy and the green spotted portions of the shaded leaves.

4. More stomata but smaller in size were found on both leaf surfaces (per unit area) in the open-grown leaves than in the shaded leaves. In both cases (open-grown and shaded) the lower epidermis had more stomata than the upper epidermis but appeared to be smaller in size and more rounded in shape.

5. Fungus hyphae were found ramifying in the parechyma tissue of the green spotted portion of the one year old crop but absent in the healthy section. In newly cured leaves, fungus hyphae were absent both in the green spotted and non-spotted portions of the leaf.

1934–1935 CROP

1. *Qualitative test for starch contents.*—Two good-sized leaves containing green spots were soaked in hot water for 10 minutes and later transferred to 95 per cent ethyl alcohol and left overnight to decolorize. Afterwards the leaves were washed with water and later treated with iodine solution dissolved in potassium iodine.

Result: Spotless portion of the leaf was colored yellowish brown and the spots formerly green became dark blue; hence, starch was absent in the normal portion of the leaf and present in the green leaf spot.

The results of chemical analysis of samples containing green leaf spots and spotless sections of the newly cured crop show that the former contains an abundance of starch and chlorophyll, which were absent in the spotless section. On the basis of this finding the following experiments were performed:

Experiment 1.—Tobacco with harvestable standard leaves and grown under shade were covered with black paper. One lot of 20 plants

were etiolated for a period of 24 hours and another set of 20 plants for 48 hours. At the end of the period 100 leaves from each lot were gathered. With the use of a big cork borer, leaf samples were taken and analyzed for its chemical content. The rest were poled and cured in the curing house for observation for the appearance of green spot.

Experiment 2.—Under the same condition as of Experiment 1, 20 shaded plants (covered for 6 weeks) were uncovered, (shade removed) and the plants exposed to full sunshine for a period of 24 hours and another group of 20 shaded plants were also exposed to full sunshine for 48 hours. After such time, 100 leaves were gathered from each set and treated similarly as of Experiment 1.

Experiment 3.—As control, 100 leaves were gathered from tobacco plants grown openly and also another set of 100 leaves from plants grown under the shade. Samples were taken for chemical analysis and the rest of the leaves were cured in the curing house.

Results: The results of Experiments 1, 2, and 3 are presented in tabulated form.

TABLE 7.—*Showing the chemical content of tobacco leaf as affected by shading and its relation to the appearance of green-leaf spot*

	Chlorophyll	Reducing sugar	Protein	Presence or absence of green leaf spot
Experiment 1:	*Per cent*	*Per cent*	*Per cent*	
Lot 1–Etiolated for 24 hours	0.041	.55	2.19	Absent.
Lot 2—Etiolated for 48 hours	0.034	.44	4.44	Absent.
Experiment 2:				
Lot 1—Exposed for 24 hours	.909	.67	2.81	Absent.
Lot 2—Exposed for 48 hours	1.537	.64	3.81	Absent.
Experiment 3:				
Plants grown under shade	0.347	0.59	2.81	Absent.
Open culture	0.177	0.55	4.5	Absent.

It is evident from the above table that the occurrence of green-leaf spots is neither correlated nor dependent upon the quantity of the chemical content of the leaf. Experiments 1 and 2 plainly show that when the shaded plants were etiolated there was a reduction in the chlorophyll content of the leaf of from 0.347 (Experiment 3) to 0.041 per cent (Experiment 1). Reducing sugar and protein also decreased; yet the cured leaves did not have green-leaf spot. In the same way when the shade of plants shaded for six weeks was removed, and the plants exposed to full sunshine, there was an increase in the amount of chlorophyll and reducing sugar, and a reduction in protein content of the leaf; still the cured leaves also did not have green leaf spot. It is, therefore, evident that even if the chlorophyll and starch

contents of the leaf are increased or decreased, green leaf spot is not produced; hence, it can be assumed that it is the external environment of the leaf both in the field and in the curing house that is responsible for the production of green leaf spot.

6. ARTIFICIAL PRODUCTION OF GREEN-LEAF SPOT

Field observations show that the occurrence of green-leaf spot is correlated with humid atmosphere, especially when the harvesting time is caught by alternating rainy and sunny days. In districts of very short dry periods as in Laguna and even in regions with distinct dry and wet seasons, as in La Union, where shading method of growing wrapper leaf tobacco is practiced, green spot only occurs in shaded plantations when very humid weather occurs at the harvest season. This is also the case in districts where open-grown method is followed as in Davao where rainfall is quite evenly distributed throughout the year. The following inquiries may then be asked: Are drops of water on the leaves when harvested conducive to green spot production? What is the effect of strong sunlight on the production of green spot when the leaves are harvested and left to wilt on the field before bringing them to the curing house? Are leaves harvested during a clear day after it has been raining for two days susceptible or conducive to the appearance of green spot? The results of the following experiments conducted in 1934–1935, which are presented in tabulated form, give the answers to these questions.

A close study of the results presented in Table 8 shows that green spots can be produced on the leaves of tobacco artificially under the conditions described therein. It is plain that moisture and heat play an important rôle in the production of green spot. Treatment No. 1 shows that when the leaves were sprayed with water previous to priming, 10 out of 50 leaves of the treated shaded plants showed green spot; after the leaves were cured, 4 of the open grown cultures, and absent when the harvested leaves were not sprayed with water. Treatment No. 4 also points out to the fact that when the leaves were heated to 70° C. for 5 minutes the color of the leaves after curing was grass green and that of those not heated was normal light brown. Again, treatment No. 5 points out that when the rays of the sun were focused with the use of a hand-lens and directed on the lamina of the leaf for one-half minute, green spots were found after the leaves had been cured and the color of the un-

TABLE 8.—*Green spot can be produced on the leaf of tobacco artificially*

Treatment [a]	Percentage of green spots	
	Open culture	Under shade
1 (*a*) Leaves sprayed with water in the morning. Harvested, poled and placed in the curing house right away to cure.	8	20
(*b*) Leaves not sprayed with water (control)	None.	None.
2 (*a*) Leaves sprayed with water. Harvested, piled in the curing house for 22 hours, then poled to cure.	14	40
(*b*) Leaves not sprayed with water (control)	None	None.
3 (*a*) Leaves sprinkled with water at 12 a. m. Harvested, piled on the ground under the sun till the drops of water dried out completely, then brought to the curing house and poled to cure.	All the leaves had patches of light green and dark flesh color.	All the leaves had patches of light green and dark flesh color.
(*b*) Leaves not sprinkled with water but placed side by side with 3 (*a*) (control).	do.	Do.
4 (*a*) Leaves not sprinkled with water were brought to the laboratory and placed in an oven and heated to 70°C. for 5 min. then poled and placed in the curing house to cure.	All the leaves had a uniform grass green color.	All the leaves had a uniform grass green color.
(*b*) Leaves not sprinkled with water and not heated. (control.)	None.	None.
5 (*a*) Leaves harvested at 11 a.m., flattened on a piece of board. Rows of drops of water placed on one-half of lamina. Rays of sunlight focused with the use of a hand-lens and directed on the lamina for ½ minute. Then the leaves were taken to curing house to cure.	Green spots were produced on spots heated with sunrays. (Fig. 3)	Green spots were produced on spots heated with sunrays.
(*b*) Leaves not treated—(control)	None	None.
6 (*a*) Leaves sprayed with water in the morning and in the afternoon for 1 hour for 2 consecutive days, and the third day, during a sunny day the leaves were harvested and cured in the usual way.	10	30
(*b*) Leaves not sprayed—(control)	None	None.

[a] Fifty leaves were used in every treatment.

treated portion of the same leaf was normal light brown (Plate 1). And, further, when the leaves were sprayed with water for some time as described in Table 8, treatment No. 6, a condition was produced that was favorable to the appearance of green spot. There were more green spots produced on the leaves of the shaded plants than on those of the open-grown plants. This was also observed in the field cultures when green leaf spot appeared naturally; hence, it may be asked, what are the differences that exist between a shaded leaf and an open-grown one?

6. ANATOMICAL STRUCTURE OF SUN AND SHADE LEAF OF TOBACCO COMPARED

When the shaded and open-grown plants were about to button, specimens were collected for anatomical study. Samples were cut at the middle on both sides of the lamina of the standard leaves and immediately immersed in Formalin-Acetic-Alcohol (70 per cent) prepared according to formula given by Chamberlain (1). They remained in the fixing fluid for 24 hours after which

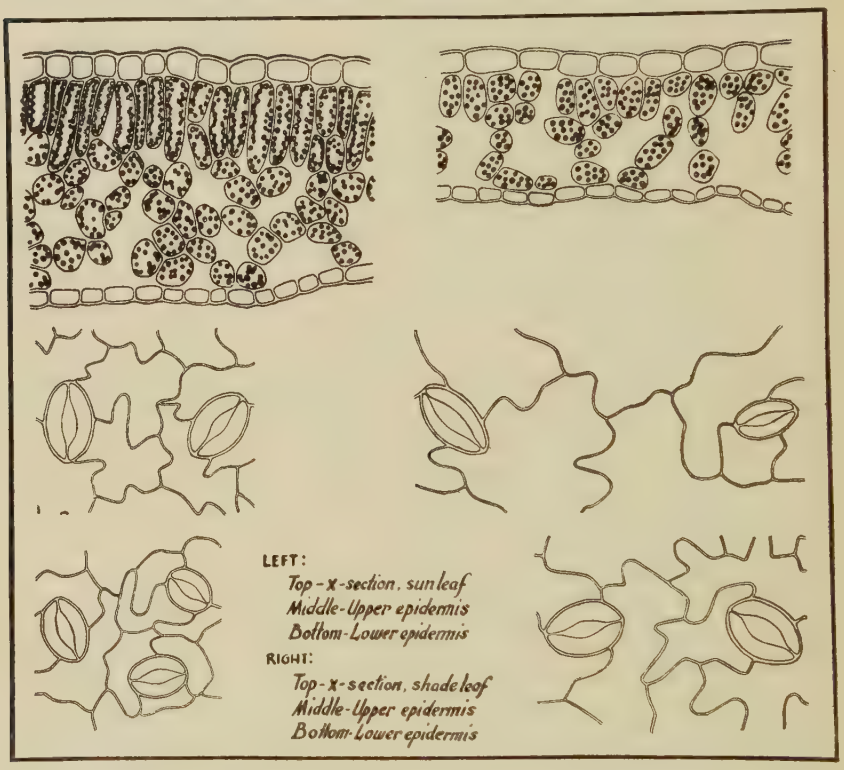

FIG. 3. Comparative leaf structure of opengrown and shaded tobacco plants. Note relative thickness of leaves and development of cuticle.

the usual histological method was followed. The sections were cut into 10 microns thick and stained with Heidenhain's iron-alum-haematoxylin with orange G dissolved in clove oil as a counterstain. Other sections were stained with Sudan III. Average section was drawn under camera lucida (Fig. 3). Portions of upper and lower epidermis of the standard leaves were peeled off and plunged right away into absolute alcohol. Later the sections were examined and drawn under camera lucida (Fig. 3).

Result: Cross-sections of fresh open-grown standard leaves averaged 308 microns thick and the shaded ones, only 166 microns (Fig. 3). The epidermal cells of the former were thicker and shorter than those of the latter. The outer wall of the upper epidermis of the open-grown leaves was greatly and highly cutinized. The epidermal wall of the shaded leaves was thin, uniform, and not cutinized. The parenchyma tissue (mesophyll) of the open-grown leaves was composed of a distinct layer of palisade cells and loosely arranged spongy parenchyma. On the other hand, the mesophyll was composed wholly of loosely arranged spongy cells. Intercellular spaces occupied more than one-half of the volume of the leaf. There were more stomata per unit area both on the upper and lower surfaces of the open-grown plants than on those of the shaded culture. The leaf structure of the shaded leaves was very much more favorable for the loss of water than that of the open-grown cultures (Fig. 3).

7. GENERAL DISCUSSION OF RESULTS AND FIELD OBSERVATIONS

(1) *Range of occurrence of green-leaf spot.*—Green-leaf spot occurs all over the Philippines in varying severity regardless of the type of the soil and of the climatic conditions existing in the locality.

The type of soil of the different tobacco districts where green spots prevail range from pure light sandy loam as in Isabela to almost clay loam as in the interior districts of La Union. In Davao and Cotabato Valley the soil is rich, dark brown, sandy loam, and the Province of Laguna has a type of soil intermediate between light sandy loam and the clay loam type.

The climate in the different tobacco districts is as variable as the soil types. In La Union Province where there are distinct dry and wet seasons, green-leaf spots appear on shaded plantations when frequent rains occur just before or during the priming season but are almost absent in the open-grown cultures. The Province of Laguna has a shorter dry than rainy period, yet the same spot malady occurs on shaded plantations when the harvesting period coincides with frequent rains and showers. The crop of 1933–1934 obtained at the Los Baños Economic Garden emphasizes this fact. In regions with no distinct dry and wet seasons but with an almost even distribution of rainfall throughout the year as in Cotabato Valley and Davao, green spots were also found to occur in the open-grown wrapper.

In view of the wide occurrence of the green-leaf spot regardless of the type of the soil and the climatic condition existing in the region, it can be presumed that the initial cause or causes of

the green spot may either be the result of the infection of a pathogenic organism or the result of disturbances in the physiological functions of the cells of the leaf or both during the curing process of the tobacco leaves. But the fact that green spots prevail on shade leaf (shaded plants) when primed and cured during a period of alternating sunny and rainy days and absent on sun leaves (open-grown) as has been found in all the tobacco regions that have this type of weather conditions; and the fact that green spots also occur in sun leaf (open-grown) when grown under a climatic condition like that of Davao and Cotabato where the atmosphere is quite very humid approaching the relative humidity of the air in shaded culture in Luzon Island, seem to indicate that the main cause of the green spot is most likely not pathogenic but more of physiological disturbances of the functions of the cells of the leaf that is being cured, caused most likely by extreme weather conditions occurring either in the field or in the curing house, or in both places during the priming and curing periods. The severity of the occurrence of the green spot depends possibly upon the chemical content of the leaf and upon its anatomical structure.

(2) *Effect of chemical content of the leaf upon the production of green-leaf spot.*—Green-leaf spot sections from newly cured leaves contain an abundance of starch granules and chlorophyll. The spotless portion of the same leaf had traces of chlorophyll only and starch granules were absent. Schloesing's data(5) on the chemical analysis of cultivated tobacco plants grown under "moist air culture" and under "usual condition" gave the following results (Table 9):

TABLE 9.—*Showing chemical content of tobacco plants grown under two different environments*

Substance	Moist air condition	Usual condition
	Per cent	*Per cent*
Urea	4.0	5.02
Nicotine	1.32	2.14
Other nitrogenous compounds	17.40	18.00
Oxalic acid	.24	6.66
Malic acid	1.91	2.79
Pectic acid	1.70	4.36
Cellulose	5.36	8.67
Starch	19.30	1.00

It is noted in Table 9 that there was 19.3 per cent of starch in the tobacco plants grown under moist air condition and only 1 per cent in the usual condition. The condition of the environment of the shaded plants grown in the different tobacco districts of Luzon is more like that of moist air condition of Schloesing's experiment. It can be deduced then that the amount of starch granules in the shaded leaves (under the abacá tent) was more than that in the open-grown cultures. Green spots occur more on shaded leaves and almost absent on open-grown cultures. It appears, therefore, that the prevalence of green-leaf spots is correlated directly with the amount of starch present in the leaf before curing, but this apparent direct correlation is not in accord with the results of the experiments described elsewhere in this paper, the data of which are presented in Table 7. The results obtained show conclusively that green leaf spot does not occur on leaves even if the chemical content is increased or lowered as the case may be.

(3) *Effects of shade upon the tobacco plant.*—The building of a shade tent of abaca cloth to a height of nine feet from the surface of the ground and enclosing the side wall with the same material produced an entirely different environment of the shaded plant as compared with the environment of the open-grown cultures. The graphs of weather factors (Fig. 2) show conclusively that weather conditions favoring transpiration are more favorable in the open-grown culture than in the shade. The records on the amount of water loss from Livingston's white spherical atmometers show that the relative transpiring power of the air daily was reduced to 71 per cent (28.8 to 20.5 cc., Table 5). This shows, therefore, that the plants under direct sunshine were growing under a more xeric environment than those in the shade. There was a modification in the structure of the tobacco leaf in response to this new habitat. Figure 3 shows that the cross-section of sun leaf (open-grown) was almost two times thicker than that of the shade leaf (shaded plants). The cuticle of sun leaf was thick and highly cutinized. The parenchyma tissue (mesophyll) of sun leaf was composed of well developed palisade cells and spongy parenchyma, whereas in the shade leaf the parenchyma tissue was made up entirely of loosely arranged spongy cells. There were more stomata per unit area both on the upper and lower surfaces of the sun leaf than on those of the shade leaf (Fig. 3).

It has been pointed out that green-leaf spot occurs most prevailingly on the leaves of shaded tobacco plants and also to a great extent on the leaves of open-grown cultures in Davao and Cotabato where the relative humidity of the air is very high which is not conducive to high transpiration. The leaf structures of the sun and shade leaves differ so much that the latter has the type of leaf adapted to mesic condition. Under adverse extreme weather conditions like high temperature, low relative humidity, and strong wind, the cells of the shade leaf are subject to rapid desiccation much faster than that of those of the sun leaf. If conditions for rapid transpiration prevail at time of harvesting, or if the nature of the curing house is such that it is conducive to rapid loss of water from the leaves, it is but natural that the shaded leaves are the ones to suffer most, the result of which would cause many cells to die prematurely due to too rapid desiccation of the protoplasm. The nature of the structure of the leaf appears, therefore, as one of the controlling factors involved in the occurrence of green spot.

Nature of the curing process.—Curing is essentially the subjecting of living leaf cells to a gradual starvation process and it involves two physiological processes; namely, respiration and translocation of mobile substances. When the leaves are primed, they are separated from the stem. They are deprived of water solution absorbed by the roots and further, when placed in the curing house, they are also deprived of sunlight necessary for photosynthethic work. Yet, the cells of the leaf, under proper conditions in the curing house, remain alive for a long while during which time respiration continues unhampered; hence, the living cells of the leaf are subjected to a process of slow starvation. It is during this period when the green color of the leaf is changed to yellow, which is chiefly due to the etiolating of the chlorophyll bodies (chemical change of the chlorophyll) because of the absence of daylight. The brown color of the tobacco leaf sets in immediately after the death of the leaf cells due to the oxidation of several different compounds contained in the cell sap. These enzyms, the oxidases, according to Loew(4), are "contained in the plasmatic living part of the cell" and not in the cell sap so that when the cells die the permeability of the plasmatic membrane is increased; hence, the oxidase and the oxidizable matter of the cell sap mix intimately and the brown-

ing of the yellow leaf sets in. Browning, therefore, takes place only after the death of the cells.

Results of experimentation show that the color of tobacco leaves that are cured quickly by too rapid drying instead of slowly as a result of slow starvation is greenish brown. Leaves of this kind when soaked in alcohol, produced a distinct green alcoholic extract. The green substance is chlorophyll. The decolorized leaf, when soaked in solution of iodine, became dark blue showing the presence of abundance of starch granules. Further, green leaf spots (Plate 1) can be produced artificially as has been described in this paper. With the green spotted leaves, when decolorized and tested for presence of starch, only the artificially green spotted portions contained starch and the adjoining sections were starchless. This is also the case with leaves with naturally produced green leaf spot. The similarity of behavior of the two kinds of spots towards reagents points out that the primary cause for the production of green spot is most likely the same or identical in both cases and is attributed to premature death of the cells at priming or during curing.

Tobacco leaves that are cured properly contain more or only trace of starch granules. This is because the reserve substances such as starches are subject to an intensive chemical transformation. The starch granules are acted upon by amylase (diastase) while the cells are still alive and converts them into sugars, namely, maltose and glucose. The soluble carbohydrates formed in the hydrolysis of starch are translocated in the leaf as sugar and takes the opposite direction, that is from the lamina to the veins for the construction of cell walls, but the greater part is consumed for respiration and disappears as carbon dioxide and water as the end products. This is the reason why the veins and midrib remain green longest in the curing house but gradually a stage is reached when the mass of the leaf turned to brown but the basal parts of the lateral veins and midrib are still fringed by strips of yellow color. In fact, Garner(2) states:

> The more or less complete disappearance of starch is one of the most characteristic changes involved in curing, and the relative freedom from starch of the cured leaf is a measure of the completeness of the curing process.

Leaves that are cured improperly, that is, by rapid drying, contain abundance of starch granules. This is due to cutting

short the activity of enzym, amylase (diastase) to convert the starch to sugars; hence, the starch granules remain intact in the cells and, therefore, are not translocated to the other parts of the leaf. Leaves that were harvested and heated immediately in an oven at 70° C. for five minutes and cured in the curing shade in the usual way, when tested for starch content after they had been in the curing house for twenty days, contained plenty of starch. Leaves not heated but cured properly contained no starch. It is evident, therefore, that curing is a life process so that anything that tends to hasten the death of the cells instead of dying slowly as the result of slow starvation, improperly cured leaves are obtained and rapid killing of the cells lead to the production of green spot on the leaf.

Primordial cause of green-leaf spot.—It has been found that green-leaf spots contain chlorophyll and starch. Improperly cured leaves have plenty of starch and the color of the finished product is greenish brown. Artificially produced green spots also contain chlorophyll and starch. Externally they are similar to green leaf spots produced naturally in the curing house. Further, it has been found that the anatomical structure of naturally produced green-leaf spots and that of artificially produced ones are the same, while their structure is different from the cross-section of a spotless leaf section. Therefore, it can be assumed that the primordial cause of the naturally produced green leaf spot or the cause of improperly cured leaves is identical to, if not the same, as the conditions that cause the production of artificial green-leaf spots. Premature death of a cell or cells of the leaves at priming or durnig curing results in the production of green spot. The chlorophyll in the green spot is the remnant of the chlorophyll in the leaf tissue which has not been etiolated due to premature death of the cells. Likewise, the starch granules are the ones left not acted upon by the amylase enzyme before the death of the protoplasm.

There are many causes of premature death of cells; namely, extremes of temperature, abundance of water, lack of air, mechanical injuries like insect bites, fungus infection, etc. The fact that artificial green leaf spots which are similar to naturally produced ones can be produced with the use of water and high temperature and the fact that the cross-sections of newly cured leaves with natural green leaf spots prepared by following the

methods used by histologists do not show any trace of fungus hyphae are proofs that the primordial causal organism of the green leaf spot is not pathogenic. The authors, however, found fungus hyphae in green leaf spot sections after the cured leaves had been aged for one year and absent in the adjoining section of the leaf. This fungus is, therefore, a saprophyte that feeds on the starch granules left intact in the green spotted portions, that is, the fungus infection came in after the death of the cells. If we take for granted that the primary cause is a fungus, then we should find leaves, free from green spot after curing, to contain green spots later on. Thus, we may ask, are there fungi, parasitic or saprophytic, on tobacco leaf capable of producing starch and chlorophyll? If there are, then it will be a big contribution to science if we could isolate them and from those organisms we could produce starch instead of getting it from plants.

It is not uncommon to find leaves that are spotted green in the curing house nor is it infrequent to find some cured leaves of commerce with green spots on them. This is due to the fact that when tobacco leaves are harvested, especially by the priming method, they are piled and left in the field, exposed to strong sunlight for some time. Under this condition, no doubt, many of the leaves are killed by desiccation either in part or in isolated spots rather than by a slow process of starvation which takes place in the curing process. The prematurely killed portions of the leaf remain green and do not change color in the curing house.

Under adverse weather conditions, it has been observed that tobacco plants grown under abacá shade produce green-leaf spot easily and rarely if not absent in leaves of open-grown cultures. This is attributed to the differences in the leaf structures of the two kinds of leaves. In the former, the leaves are thin, thin—cuticled and not cutinized, and there are no palisade cells (Fig. 3). The open-grown leaves are thick, thick—cuticled with highly cutinized cell walls and with a well developed layer of palisade cells. This type of leaf structure is not conducive to easy dehydration of the protoplasm but the leaf structure of the shaded plant is such that it is adapted to mesic habitat. Thus, under a condition favorable for rapid transpiration, as high temperature, the leaf loses its water easily and if continued for some

TABLE 1.—*Showing some weather records observed at the Los Baños Economic Garden, Los Baños, Laguna, during the 1933–1934 tobacco season when the green spot was very severe. (Observations were taken at 12 a. m.)*

Date	Soil temperature			Air temperature			Relative humidity		
	Open culture	Shade culture	Difference	Open culture	Shade culture	Difference	Open culture	Shade culture	Difference
	°C.	°C.	°C.	°C.	°C.	°C.	*Per cent*	*Per cent*	*Per cent*
2– 9–34	26.00	25.80	0.20	26.00	22.00	4.00	69.00	71.00	8.00
2–10–34	25.50	25.00	0.50	26.10	21.20	4.90	62.00	80.00	8.00
2–11–34	25.20	24.90	0.30	26.40	21.60	4.80	63.00	74.00	11.00
2–12–34	25.50	24.50	1.00	29.50	22.90	6.60	54.60	60.00	5.00
2–13–34	25.40	40.30	1.10	25.10	21.60	3.50	62.00	82.00	20.00
2–14–34	25.50	24.50	1.00	28.70	22.60	6.10	51.00	71.00	20.00
2–15–34	25.60	25.60	0.00	28.10	22.20	5.90	60.00	73.00	13.00
2–16–34	25.50	24.50	0.90	26.80	28.80	4.00	65.00	79.00	14.00
2–17–34	25.30	24.50	0.30	26.70	24.30	2.40	70.00	83.00	13.00
2–18–34	26.00	24.50	1.20	24.40	24.00	0.00	99.00	100.00	1.00
2–20–34	26.00	24.70	1.30	29.40	23.30	5.10	64.00	73.00	9.00
2–21–34	25.60	24.50	0.6	27.20	24.40	2.80	70.00	81.00	11.00
2–23–34	25.50	24.80	0.7	27.80	26.70	1.10	74.00	83.00	9.00
2–24–34	25.40	25.00	0.4	36.60	28.90	1.70	72.00	80.00	8.00
2–26–34	26.00	25.60	0.4	34.40	28.80	5.60	65.00	65.00	0.00
2–27–34	26.20	25.50	0.7	32.80	26.70	6.10	73.00	76.00	3.00
2–28–34	26.70	25.80	0.9	31.20	28.00	3.20	69.00	76.00	7.00
3– 1–34	26.80	25.80	1.00	33.90	28.50	5.40	62.00	67.00	5.00
3– 2–34	27.00	26.00	1.00	35.60	34.60	1.00	56.00	78.00	14.00
3– 4–34	27.00	26.00	1.00	27.50	23.90	3.60	73.00	79.00	6.00
3– 5–34	27.00	25.10	1.90	28.90	23.30	5.60	61.00	63.00	2.00
3– 6–34	26.50	25.00	1.50	29.40	25.60	3.80	72.00	80.00	8.00
3– 7–34	26.00	24.90	1.10	27.80	22.80	5.00	63.00	66.00	3.00
3– 8–34	26.00	24.90	1.10	30.60	23.30	7.50	51.00	57.00	6.00
3– 9–34	26.00	24.90	1.10	31.10	23.60	7.50	51.00	61.00	10.00
3–10–34	26.00	24.90	1.10	28.30	23.90	4.40	68.00	74.00	6.00
3–12–34	26.00	25.00	1.00	34.40	28.30	6.10	61.00	68.00	7.00
3–13–34	26.50	25.00	1.00	35.00	27.80	7.20	56.00	70.00	14.00
3–14–34	27.00	26.10	0.90	35.40	27.80	7.60	53.00	62.00	9.00
3–15–34	27.00	26.00	1.00	31.90	25.00	6.90	59.00	71.00	12.00
3–16–34	27.30	26.50	0.80	28.30	24.70	3.60	73.00	78.00	5.00
3–17–34	27.50	26.00	1.50	25.60	22.80	2.60	77.00	82.00	5.00
3–19–34	26.40	25.00	1.40	27.20	23.90	3.30	74.00	82.00	8.00
3–20–34	26.60	25.10	1.50	30.00	26.70	3.30	76.00	76.00	0.00
Average..	26.16	25.18	0.9	27.15	24.67	4.50	65.53	73.91	8.02

time the protoplasm would be dehydrated and ultimately the cells die. In fact, numerous investigators have observed that the cause of death of many leaves under adverse climatic conditions seem to be due to the dehydration of the protoplasm rather than to a critical temperature. On the other hand the leaves of open-grown cultures are in a position to restrict rapid transpiration because of the nature of their leaf structure. According to Weaver and Clements(6),

TABLE 2.—*Average weekly air temperature at the Los Baños Economic Garden (1935)*

Date of observation	Under shade				Exposed			
	8 a. m.	12 a. m.	5 p. m.	Average	8 a. m.	12 a. m.	5 p. m.	Average
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
Feb. 2–9	24.4	29.1	27.8	27.1	24.3	29.1	28.2	27.2
Feb. 10–16	25.4	28.4	26.1	26.6	25.0	29.8	25.4	27.1
Feb. 17–23	24.4	28.8	26.5	26.6	23.7	29.0	27.1	26.6
Feb. 24–Mar. 2	26.9	31.0	28.5	28.8	26.8	31.6	30.0	29.5
Mar. 3–9	25.1	28.3	28.4	27.3	24.4	28.8	27.2	26.8
Mar. 10–16	25.9	30.4	29.2	28.5	25.4	31.8	30.8	29.3
Mar. 17–23	27.5	32.4	30.8	30.2	28.2	34.0	30.9	31.0
Mar. 24–30	27.7	32.8	31.6	30.7	28.7	34.9	32.0	31.9
Mar. 31–April 6	27.4	32.6	30.7	30.2	27.0	34.6	30.9	30.8
April 7–13	28.1	32.5	31.7	30.8	29.0	33.0	32.0	31.3
April 14–20	28.7	33.4	31.9	31.3	29.9	34.7	30.9	31.8
April 21–27	29.6	33.8	33.6	32.3	30.5	35.3	33.1	32.9
April 28–May 4	29.2	32.8	29.8	30.6	29.8	34.0	29.8	31.2
Average	26.9	31.3	29.7	29.3	27.1	32.4	29.9	29.8

TABLE 3.—*Average weekly soil temperature at the Los Baños Economic Garden (1935)*

Period of observation	Under shade				Exposed			
	8 a. m.	12 a. m.	5 p. m.	Average	8 a. m.	12 a. m.	5 p. m.	Averag
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
Feb. 2–9	24.1	25.4	26.1	25.2	25.0	26.4	27.2	26.2
Feb. 10–16	25.0	25.5	26.0	25.5	25.7	26.0	26.6	26.1
Feb. 17–23	25.1	25.1	25.6	25.3	25.6	26.1	27.0	26.2
Feb. 24–Mar. 2	25.0	25.4	25.9	25.4	26.3	27.1	28.1	27.2
Mar. 3–9	25.3	25.4	25.7	25.5	26.6	27.1	28.0	27.2
Mar. 10–16	25.2	25.2	26.1	25.5	26.8	27.7	29.2	27.9
Mar. 17–23	26.5	26.8	29.2	27.5	28.1	30.1	31.6	29.9
Mar 24–30	26.4	27.0	29.7	27.7	28.8	30.5	31.7	30.3
Mar. 31–April 6	26.9	27.5	28.6	27.7	29.5	31.4	32.5	31.1
April 7–13	26.7	27.1	28.2	27.3	28.7	30.6	31.9	30.4
April 14–20	27.1	27.7	28.9	27.9	29.8	31.9	33.3	31.7
April 21–27	29.5	28.7	30.0	29.4	31.1	33.9	34.0	33.0
April 28–May 4	27.9	28.7	29.1	28.6	30.0	33.0	33.4	32.1
Average	26.2	26.6	27.6	26.8	27.8	29.4	30.3	29.2

Among the most common adaptation for decreasing water loss are heavy cuticularization and extreme cutinization of the epidermis . . . The formation of cuticle is the most perfect of all devices for decreasing permeability and thus reducing transpiration . . . In addition to reducing water loss, the thick cuticle affords protection against mechanical injury by wind, insects, and grazing or browsing animals and also from invasion by fungi.

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TABLE 4.—*Average weekly relative humidity at the Los Baños Economic Garden (1935)*

Date of observation	Under shade				Exposed			
	8 a. m.	12 a. m.	5 p. m.	Average	8 a. m.	12 a. m.	5 p. m.	Average
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Feb. 2–9	80.8	64.8	61.0	68.9	77.0	60.8	60.5	66.1
Feb. 10–16	82.0	69.3	73.8	75.0	80.8	59.3	70.3	70.1
Feb. 17–23	80.3	66.4	75.4	74.0	79.2	64.0	74.2	72.5
Feb. 24–Mar. 2	80.5	58.0	63.3	67.3	80.0	57.3	60.5	65.9
Mar. 3–9	80.6	64.0	64.5	69.7	79.5	63.3	63.6	65.5
Mar. 10–16	81.3	56.1	62.8	66.7	80.0	54.8	61.3	65.4
Mar. 17–23	77.1	58.8	54.8	63.6	75.3	55.5	53.6	61.5
Mar. 24–30	78.3	50.8	46.8	58.6	72.3	44.8	44.1	53.7
Mar. 31–April 6	76.3	55.0	57.1	62.8	75.1	52.8	55.3	61.1
April 7–13	74.8	58.8	59.7	64.4	71.0	56.1	54.3	60.5
April 14–20	69.5	55.2	57.0	60.6	67.5	51.2	44.0	54.2
April 21–27	70.5	53.3	52.5	58.8	66.0	48.3	50.3	54.8
April 28–May 4	79.2	73.6	83.4	78.7	78.4	71.0	82.0	77.1
Average	77.8	60.3	62.5	66.9	75.4	56.6	69.5	62.8

TABLE 5.—*Average weekly evaporation*[a] *at the Los Baños Economic Garden (1935)*

Date of observation	Under shade	Exposed	Difference
	c. c.	*c. c.*	*c. c.*
Feb. 2–9	139.8	197.8	58.0
Feb. 10–16	90.0	144.0	54.0
Feb. 17–23	98.6	147.8	49.2
Feb. 24–Mar 2	114.6	166.3	51.7
Mar. 3–9	124.3	175.8	51.5
Mar. 10–16	151.1	209.7	58.6
Mar. 17–23	139.3	196.3	57.0
Mar. 24–30	165.7	232.1	66.4
Mar. 31–April	170.8	242.0	71.2
April 7–13	131.7	189.8	58.1
April 14–20	198.0	256.3	58.3
April 21–27	221.0	284.4	63.4
April 28–May 4	125.4	176.2	50.8
Daily average	20.5	28.8	8.3

CONCLUSION

1. Green-leaf spot occurs all over the Philippines regardless of the type of soil and condition of climate in which the leaf wrapper type of tobacco is grown. Tobacco plants that are grown under shade of abaca cloth develop green leaf spots easily. Rarely if not absent in open-grown cultures in the tobacco dis-

TABLE 6.—*Daily rainfall at the Los Baños College of Agriculture*[a] *(1935)*

Date	January	February	March	April	May
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
1	4.06				
2					
3	1.02				
4					
5					
6			2.54	11.94	
7				9.14	
8					
9		33.02			
10					
11	Trace				
12					
13					
14					
15		2.54			
16	2.03	1.27			
17	.25	1.27			
18					
19	2.04	2.03			
20		3.81			
21					
22	4.06				
23	6.60	.76			
24	7.62	1.27			
25	2.03	3.05			
26					
27					
28					
29				3.81	
30					
31					
Total	29.71	49.02	2.54	24.89	

[a] College of Agriculture is 2.5 Km. from Los Baños Economic Garden.

tricts of Luzon it is also abundant in Cotabato and Davao where the atmosphere is very humid.

2. Green-leaf spot contains abundance of chlorophyll and starch but the occurrence of green leaf spot is not correlated with the amount of chemical content of the leaf previous to priming. Under normal conditions in the curing house, green leaf spot does not occur in leaves even if the chemical content of the leaf is increased or decreased by external treatment.

3. The severity of the occurrence of green leaf spot is directly correlated with the structure of the leaf. It occurs more on the leaves of shaded plants, or plants growing in places with very high humidity, where the type of the leaf is adapted to mesic environment, and rarely on the leaves of open-grown cultures that have a xeric type of leaves (Fig. 3).

4. Extremes of weather conditions during the curing process favor the production of green leaf spot, the shaded leaves being the ones affected most.

5. The primordial cause of green leaf spot is most likely not pathogenic, but the disturbances of the physiological functions of the cells which are cut short due to premature death of the cells on account of extremes of temperature, abundance of moisture, lack of air, or rapid dehydration of the protoplasm. Green leaf spot identical to, if not the same as, naturally produced green leaf spot can be produced artificially with the application of heat and distilled water on the lamina of the leaf.

RECOMMENDATIONS

It is an admitted fact that green-leaf spot occurs during curing. Results of investigations show that premature death of the cells lead to the production of green spot. The farmer, therefore, should be very careful about his crop during curing time. The leaves should be harvested when there is no moisture film on the surface of the leaves and that unless leaves are to be taken immediately to the curing house harvesting must not be done during noon time.

Leaves that are properly cured should die slowly as a result of slow starvation and at the same time they should be allowed to lose their water gradually. To regulate the rate of drying of the leaves is the most important step in the curing process. If the leaves dry too rapidly the cells are killed prematurely. Therefore, the green pigment is not all converted to yellow and the curing is stopped. On the other hand, if the rate of drying is too slow, the curing goes far.

The rapidity of the leaves to dry in the curing house depends principally on the relative humidity of the air. The most favorable temperature for the first week in the curing house should lie around 27° C. and the relative humidity of the air about 75 per cent. Under these conditions the leaves will gradually lose their water content through transpiration. When the leaves begin to turn brown then there is no longer need for keeping the air in the barn moist, and the leaves may be allowed to dry rapidly.

A curing house should be built such that it could be made dark inside at will and at the same time the temperature of the air and relative humidity could be controlled at any time. Unfor-

tunately, the mass of our farmers at the present time have very limited means and they depend only upon nature's will.

In regions with an even distribution of rainfall where the open-grown culture of growing leaf wrapper tobacco is practised, efforts should be made to have the harvesting season when the relative humidity is lowest. In regions with distinct dry and wet seasons more attention should be directed to the building of good curing houses so that the conditions requisite for good curing would be met with at will.

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ILLUSTRATIONS

Plate 1

Artificially produced green-leaf spot. Focused sun rays directed on drops of water placed on the lamina of the leaf produced the spot.

TEXT FIGURES

Fig. 1. Graph of weather records observed at the Los Baños Economic Garden when green-leaf spot was rampant.

2. Graph of weather records observed at the Los Baños Economic Garden when green leaf spot was practically absent.

3. Comparative leaf structure of open-grown and shaded tobacco plants. Note the relative thickness of leaves and development of cuticle.

PLATE 1.

A SURVEY OF THE PLANT DISEASES IN MARIDAGAO, PIKIT, COTABATO, WITH SOME SUGGESTIONS FOR THEIR CONTROL

By Evaristo A. Hurtado

Of the Bureau of Plant Industry, Manila

SIX PLATES

While the writer was engaged in laying out a continuation of an experiment on the control of cacao black-pod disease in the Maridagao Rubber Experiment Station in 1934, opportunities to observe other diseases on various trees grown in that region were utilized to good advantage. Some valuable information not previously known from that region had been gathered during those observations. The suitability of that region for the culture of various fruit trees because of rich soil, favorable climate and other agronomical factors, offer good inducements to fruit growers. However, no information of the prevalence of diseases appears to be available. The result of this plant disease survey may be of interest to the planters and prospective planters of Cotabato. A brief description of the symptoms of the disease and suggestions for control are included in these brief notes.

CACAO DISEASES

The bearing trees are attacked by die-back, black-rot and canker diseases. The die-back has killed a few trees. Severe infection reaches as high as 90 per cent and the trees are attacked from the branches down to the trunks.

In the case of the young plants the die-back has killed[1] about 20 per cent, severely[2] infected, 39 per cent, slightly[3] infected, 28 per cent, and the rest which is 13 per cent are healthy.[4] The black-rot infects buds, flowers and pods. The canker attacked young and bearing trees.

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[1] The stem is already dried and no sprouts are coming out of the base.

[2] The infection has killed the main stem and new shoots are coming out of the base.

[3] The infection is just at the tip of the main stem.

[4] No signs of infection.

DIE BACK

The first noticeable symptom is the turning brown of the twig, seedling or sprout, later followed by drying (Plate 1). The progress of the disease is shown by a continuous drying of the leaves beginning from the youngest to the oldest. It continues downward to the main branches, and down to the stem. When the infection has reached the main branches, there is a multiple production of sprouts on the twigs, branches, and trunks. But sooner the sprouts dry up beginning on those on the twigs and followed by those on the branches. A seriously infected tree appears as if it has suffered from the effects of burning. Splitting lengthwise or cutting crosswise an infected twig, the branch of the trunk would show a brown discoloration of the wood fibers.

Isolation from diseased twigs shows the association of a species of *Gloeosporium*.

BLACK-ROT

On the bud or flower, black-rot infection begins on any part of its parts. Oftentimes fresh symptoms of the disease are hard to be noticed until at least one-third of the whole bud or flower is infected. The first symptom is characterized by small somewhat water tint brown lesions. Later the whole infected area turns brown to black. Diseased buds or flowers dry up and either fall or remain in the flower cushion for sometime. During moist days white threads of mycelium is found associated with the diseased flower cushions.

On immature pods, the fresh symptoms are the small, water soaked, brown patches on any part of the pod. In most cases the infections are first noticed at the end or at the base of the peduncle attachment. The disease progresses so rapidly that the entire fruit turns brown in a few days. Later it shrivels and turns black. A diseased fruit either remain on the tree or fall to the ground.

A species of *Fusarium* is found associated with the lesions of the diseased pods.

SUGGESTIONS FOR THE CONTROL OF DIE-BACK AND BLACK-ROT DISEASES

1. Prunning to remove diseased parts.
2. Dinsinfecting the fresh wound with disinfectant such as Bordeaux paste, Formalin or Mercury bichloride and then paint the disinfected wounds with lead paint.

3. Proper disposal of removed diseased parts (branches, twigs, leaves, and fruits).

4. Spraying thoroughly with standard Bordeaux mixture spray.

5. Avoid too much humidity in the cacao atmosphere by cutting down the grasses low and pruning of permanent shade trees.

6. Control of insects by the application of insecticides since they spread the disease organisms and may predispose the trees to infections through injuries.

a. For leaf or shoot feeding insects use lead arsenate, 3 grams to be added to every liter of prepared Bordeaux mixture spray. Or use calcium gawgaw in the form of dust. Dust early in the morning.

b. For aphids and other soft bodied insects use "Black leaf 40", 1 cubic centimeter to be added to every liter of Bordeaux mixture spray.

CANKER

Microscopically, the first noticeable symptom is the presence of small, round, brown raised specks about half a millimeter in diameter on the surface of the bark. Some are scattered and some are in regular rows parallel to the axis of the infected twig, branch or trunk. As the canker lesions become older they expand in diameter and in height and finally crack at the top surface. Some old canker lesions are from one and one-half to three millimeters in diameter, dark-brown and very rought to the touch (Plate 2). Some form ridges by the coalescence of the lesions in the rows along the trunk. In cases where the attacked portion is already dead, the canker lesions become white because of the exposure of the mycelial growth therefrom (Plate 3).

Phytopthora faberi is associated with the lesions. Spraying the trees thoroughly with Bordeaux mixture for the control of black pod protect healthy trees.

COFFEE DISEASES

COFFEE BLIGHT

A thread blight disease was found to be serious. In a portion of the coffee plantation of Maridagao which was poorly drained and ill kept, an infection of about 70.3 per cent was observed. The plants were yellowing, stunted, partly defoliated, flowers and berries drying up and some trees were already killed. However, in another portion which was properly drained and well kept, the infection was about 1.3 per cent. The plants were vigorous and heavy yielders.

Infection by this disease is very conspicuous in the field. Usually the foliage on the lower branches are the first ones to be attacked probably because of being more moist than those on the upper branches. The infected leaves blacken. Some of the dead leaves when detached are suspended with the fungus hyphae (Plate 4). The attacked flowers and fruits are clumped together by the mycelium. The infected twigs are killed and if the twigs are infected the tree dies of defoliation.

The disease is associated with a thread fungus, the vegetative part of which forms long, whitish gray strands running along the branches and twigs, infecting the flowers, fruits, and leaves (Plate 5). It clumps and covers the flowers and fruits rendering them white in appearance. On the under surface of the leaves it ramifies forming a whitish mat fungus hyphae (Plate 6). When the hyphae is dry it can be peeled off.

PINK DISEASE

A coffee tree infected with pink disease may be recognized by the presence of dead branches. A pinkish to salmon growth of the fungus mass is found on the bark. The bark cracks. In some cases of infection the trunks, flowers, and fruits are attacked. When the infection on the trunk is complete, the tree die.

The fungus on the diseased stem is *Corticium salmonicolor* B. & Br.

CONTROL OF BLIGHT AND PINK DISEASES

For both diseases the infected part of the coffee tree as well as the shade trees must be removed. Fresh cuts must be disinfected with Bordeaux paste, formalin or mercury bichloride and then painted with lead paint. Because these diseases are favored by moist situation, the grasses must be cut low and the shade trees must be pruned. If it is possible spray the trees with Bordeaux mixture.

ROOT-ROT

A tree infected with root-rot wilts gradually until the leaves fall off and dry. The tree does not recover at all because the root system is killed. To save the neighboring trees the infected plant must be dug including as much as possible of the roots. Apply lime to the hole and leave it uncovered for about six months. Uproot all shade trees infected with root-rot as they serve as source of infection to the coffee plants. Trenching to prevent infection of other trees should be practised.

RUBBER DISEASE

PINK DISEASE

Infection is noticed easily by the presence of dead branches, partly living hanging branches, dead crowns and the production of numerous shoots just below the lesions. Infection is observed to be most common at the base of the main branches. The barks crack and a pinkish salmon fungus mass is found on the diseased bark.

Corticium salmonicolor B. & Br. was readily found on the diseased parts.

To control this disease pruning of infected branches, twigs, and crowns is the most recommendable.

CITRUS DISEASES

GUMMOSIS

This disease is common during moist days. The trees attacked are stunted and show yellowing of foliage. The oozing out of gummy substance through the bark is the most recognizable characteristic of the disease.

The application of disinfectant and later painted with good paint after bark scraping of the infected parts prove to be a good measures to control the disease. The soil must be well drained as wet soil favors the development of the disease.

CANKER

Canker attacks the seedlings in the nursery as well as those big ones planted in the field. It is recognized by the presence of yellowish, regular or irregular, rough, different size of lesions on the leaves, twigs, and fruits typical of the symptoms produced by the bacterium (*Phytomonas citri*).

Only healthy seedlings must be planted in the field. Spraying with fungicides like Bordeaux mixture and lime-sulphur may be recommended. The use of resistant varieties and strick sanitation help a great deal to control the disease.

ILLUSTRATIONS

PLATE 1

Cacao twig attacked by die-back disease. Note the drying up of the tip. (Specimen from Maridagao. Photographed by the Department of Agriculture and Commerce, October 25, 1934.)

PLATE 2

Portions of cacao trunk showing the canker lesions on the bark. (Specimens from Maridagao. Photographed by the Department of Agriculture and Commerce, October 25, 1934.)

PLATE 3

Portions of the cacao trunk showing the white growth of the mycelium from the canker lesions. (Photographed by the Department of Agriculture and Commerce, October 25, 1934.)

PLATE 4

A coffee twig killed by thread blight fungus disease. Note the leaves suspended by the mycelial hyphae. (Maridagao Rubber Experiment Station, October 8, 1934.)

PLATE 5

A coffee twig infected with thread blight fungus disease. Note the hyphae spreading to the leaves. (Specimen from Maridagao. Photographed by the Department of Agriculture and Commerce, October 25, 1934.)

PLATE 6

Coffee berries attacked by thread blight disease. Note the fungus clumping the fruits and ramifying on the under surface of the leaf forming a whitish mat. (Specimen from Maridagao. Photographed by the Department of Agriculture and Commerce, October 25, 1934.)

PLATE 1.

PLATE 2.

PLATE 3.

PLATE 4.

PLATE 5.

PLATE 6.

SOME OBSERVATIONS ON TWO SCALE INSECTS INJURIOUS TO MANGO FLOWERS AND FRUITS

By F. Q. Otanes

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SEVEN PLATES

The direct injuries to plants caused by sucking insects that puncture them and suck their juice are enormous. Some sucking insects, however, are dangerous, indirectly, as carriers or vectors of the causal organisms or pathogenes of plant diseases. According to Wardle (1929), the evidence as to the rôle of insects, both sucking and biting, in plant disease transmission is as yet meager and the subject is one of comparatively recent investigation. The possibilities of some sucking insects, particularly the mealy bug, *Trionymus sacchari* Ckll., serving as transmitters of some sugar cane diseases in the Philippines were briefly discussed by Uichanco and Villanueva (1932). One of the few local works in which experimental evidence is given as to the ability of certain sucking insects to transmit certain plant diseases is that by Ocfemia (1934) wherein it is shown that the adults of the cane leaf hopper, *Perkinsiella vastatrix* Breddin, transmit the virus of the Fiji disease of cane.

Along with the impetus that is being given to mango production it is advisable to study especially the sucking insects that attack the mango plant, particularly the flowers and fruits, and which are most likely to play an important part in disease transmission because of the nature of their injury to the plant. Among the sucking insects attacking the mango, the most important are the leaf hoppers *Chunra* [1] *niveosparsa* Leth. and *Idiocerus clypealis* Leth. These have been studied to some extent,

[1] Dr. Gonzalo Merino, Chief, Plant Pest and Disease Control Division, has made a study of Philippine Cicadellidae and has used the genus *Chunra*, as given by Woodworth (1921) in place of *Idiocerus*, in recent papers (1934) and (1935). The latter, however, according to him, should be used for the other species (*Iidocerus clypealis*) instead of *Idioscopus* as listed by Woodworth.

and different control measures, particularly spraying with soap solution, have been used since 1923, by the old Bureau of Agriculture and later by the Bureau of Plant Industry, not only against mango hoppers but also against other insects, especially locust hoppers and coconut leaf-miner beetles, *Promecotheca cumingi* Baly (Otanes 1923, 1925, 1931 and Otanes and Butac 1925). Owing to many factors, however, such as the presence of other insects and the delicate nature of mango flowers, spraying the flowers to kill the hoppers with soap solution or soap suds has not always produced satisfactory results. F. del Rosario and G. Bellosillo, of the entomology staff of the Bureau of Science, have obtained some data on the life history of the above-mentioned leaf hoppers, their data having been embodied in a paper by Serrano and Palo (1933). These latter two investigators reported that they obtained good results with laundry soap solution sprays at Muntinlupa, Rizal. In a recent paper (1935), Palo and Garcia, on the basis of their recent observations at Novaliches, Rizal, advise caution in the use of laundry soap suds on mango flowers.

So far, practically no attention has been given to the scale insects [2] that attack mango, some of which, like the hoppers have been found injurious to the flowers. It is an open question as to whether the drying up of the mango flowers is, in some cases, due in large or small measure, to some diseases and whether the scale insects, together with the hoppers and other sucking insects, such as thrips, play an important rôle in the transmission of the causative agents of such diseases.

In connection with the work on the pests and diseases of the mango began late in 1932 in the mango plantation of Dr. Nicanor Jacinto, at Novaliches, Caloocan, Rizal, by Dr. F. M. Clara,

[2] Besides the two species dealt with in the article, Woodworth (1921) lists the following other species of scale insects on mango; namely, *Aspidiotus destructor* Sign., *Aspidiotus translucens* Ckll., *Phenacaspis inday* Banks, *Tacchardia minuta* Morr., and *Vinsonia stellifera* Wesw. I have found a species of *Lepidosaphes* rather common and injurious to the mango. As far as I have been able to ascertain specimens conform to the characters of *Lepidosaphes mcgregori* Banks. However, specimens have been sent to Dr. Harold Morrison, in charge of the Division of Insect Identification of the United States Bureau of Entomology and Plant Quarantine, for identification, together with those of two other scales on mango. *Ferrisiana virgata* Ckll. and *Pseudococcus lilacinus* Ckll. have also been collected from the mango. A species of *Chionaspis* and of *Ceroplastes* have likewise been collected.

plant pathologist, and the present writer, and which was later continued by Messrs. Macario Palo, assistant plant pathologist, and C. E. Garcia, assistant agronomist, two scale insects (*Puto spinosus* Robinson and *Coccus mangiferae* Green) were observed abundant and harmful so as to warrant a report about them in an article. It should be stated in this connection that a number of caterpillars, including those of *Chlumetia transversa,* and a species of *Eutelia,* as well as some tortricid and other moths have also been observed to attack the flowers of mango. Thrips have likewise been observed abundant and are apparently also injurious to the flowers. The Chrysomelid beetle, *Monolepta bifasciata,* is also known to attack mango flowers. There is probably no other fruit tree in the Philippines that attracts and holds more insects than does the mango, especially during the flowering season. In the application of control measures against the mango hoppers, it is obviously advisable to take into account all these other insects, as well as other factors, such as the effect of frequent rainfall when the flowers are in full bloom, of strong winds and natural fruit shedding, as failure to control the mango hoppers owing partly or chiefly to the unexpected occurrence of one or all of the uncontrollable factors may be erroneously attributed to the methods of control themselves.

MEALY BUGS

PUTO SPINOSUS

(Plates 1, 2, 3, 4)

This mealy bug was found prevalent and abundant in the mango orchard of Dr. Nicanor Jacinto, at Novaliches, Caloocan, Rizal. In fact it was found more abundant in some trees than the mango hoppers. When first collected in 1932, it was thought to be another species, *Pseudococcus lilacinus,* which it resembled suprficially under field conditions in external appearance and in gregariousness. Careful examination of stained adult specimens, however, revealed the insect as possessing all the characters of *Puto spinosus* Robinson, as given by Morrison (1920), the most important of which characters being the presence of groups of truncate spines along the entire margin of the body (Figs. 1 and 2, Plate 4). Each tarsal claw has a tooth or denticle. Robinson (1918) described the insect under the genus *Phenacoccus* from specimens collected from *Ficus nota* by R. C. McGregor. Morrison (1920) placed it under the genus *Puto.*[3]

[3] Considered by Ferris (1918) as a synonym of *Ceroputo.*

He also described and figured one species from the Philippines under the genus *Phenacoccus,* namely, *Phenacoccus hirsutus* Green, but he doubted whether this would remain under the genus when any generic revision of the subfamily (*Doctylopiinae*) is undertaken. *P. hirsutus* Green is without a tooth in each tarsal claw, according to Morrison.

Specimens of *Puto spinosus* have been collected from the nests of the common red tree ants, *Oecophylla smaragdina.* During the flowering season of mangos at Novaliches, that is, beginning November, the mealy bugs are commonly observed abundant on the flowers and fruit stems and on the young twigs and leaves and are attended to by the red ants, which are generally abundant in the mango plantation of Doctor Jacinto.

Since this species was first observed by the writer at Novaliches in 1932, specimens have been collected from other places. Mr. C. E. Garcia has collected some from mango flowers at Muntinlupa, Rizal. Mr. A. G. Toquero, assistant agronomist, has also collected specimens from Palanguit, Naic, Cavite.

Morrison (1920) gives the following records of host plants in Luzon:

> Manila, on "wild plants" (Compere 20194), (Compere 20233); Baliwag, Bulacan, on *Tabernaemontana* sp. (coll. Arce 2619); Katagpo, on *Antidesma leptocladum* (coll. Arce 2615); Rizal Province, Balintawak on *Mangifera indica* (coll. Arce 2599).
>
> These records indicate that the species is wide-spread, at least in Luzon.

Mr. Garcia has collected it from *Buchanania arborescens*[4] Blume at Novaliches, Rizal. This plant belongs to the same family (*Anacardiaceae*), as mango.

According to Takahashi (1929) this species also occurs in Formosa, but the host plant is unknown.

DESCRIPTIONS AND OBSERVATIONS ON THE BIOLOGY OF PUTO SPINOSUS

The young.—The newly born young is pale yellow and is about 0.2 millimeters long and 0.1 millimeter wide. In the Entomology Laboratory at Singalong, Manila, the wax secretions and the appendages or filaments became conspicuous in about two days (Plate 3, fig. 1). Nymphs before molting for the first time and after molting are shown by figs. 2 and 3, Plate 3, respectively. The most apparent observable external change after each

[4] Identified by Mr. E. Karganilla, of the Bureau of Science, through Mr. C. E. Garcia.

molt was the increase in the length of the wax fringes or filaments, especially the posterior or anal ones. Mounted specimens of first instar nymphs reveal five antennal segments (Plate 3, fig. 5).

The adult female.—The adult female is about 2 millimeters long and 1.5 millimeters wide. The wax secretions are white. Females reared in the laboratory, in the greenhouse, were found to produce conspicuously longer wax fringes or filaments (Plate 1, fig. 1), than those collected from the field (fig. 2, Plate 1), as to resemble certain species of *Phenacoccus*. In some cases the anal wax filaments were from 1.5 to 2 centimeters long. The insect has nine antennal segments and each tarsal claw has a small tooth or denticle. The most important character is the presence of groups of truncate spines together with wax pores along the entire margin of the body (Plate 4).

No male has been reared so far from specimens collected from the field or from cultures raised on mango seedlings in pots in the laboratory. It is likely that the insect is wholly parthenogenetic, or is capable of reproducing wholly parthenogentically.

From rearing records obtained so far under greenhouse conditions at Singalong, Manila, the period from the time of birth of the young mealy bugs to the time when they produced young is about two months.

COCCUS MANGIFERAE GREEN

(Plates 5, 6, 7)

Another unarmored or nondiaspine scale insect noticed by the writer on mangos at Novaliches in November, 1932, along with *Puto spinosus*, is a species of *Coccus*. Examination of mounted specimens showed them to agree with the characters of *Coccus mangiferae* Green, as given by Morrison (1920) and by Green (1896). This scale insect was first reported by Morrison in 1920 from specimens collected by Mr. R. C. McGregor from coconuts at Paete, Laguna. It has not, however, been reported locally on the mango, so far as the present writer has ascertained. The species was described by Green (1896) under the genus *Lecanium*. This species is also recorded in Formosa by Takahashi (1929), the mango being one of the host plants.

On mango flowers the effect of the work of *Coccus mangiferae* Green resembled very much that of mango hoppers, the flowers affected having withered and fallen off and the peduncles of the flowers and leaves on which the honeydew of the scales had

fallen showed conspicuously sooty mold growth. Only close examination showed the injury as being due to this scale and not to hoppers. The scales were attended to by tree ants, *Oecophylla smaragdina*. The scale has also been collected in Manila from the nests of these ants by Mr. A. G. Toquero. Mr. C. E. Garcia has collected it from the nests of the same kinds of ants on mango trees in Bacolor, Pampanga, and later in Muntinlupa, Rizal. Mr. Toquero has also collected it from mangos in Naic, Cavite, together with *Puto spinosus*, both being attended to by the red ants, *Oecophylla smaragdina*.[5]

Rearing of this species in the greenhouse at Singalong has so far failed.

DESCRIPTIONS

Egg.—Pale yellow, ellipsoidal and is about 0.28 millimeter long and 0.18 millimeter in diameter. The eggs turn brownish before hatching.

The nymph.—The newly hatched nymphs is about 0.3 millimeter long and 0.2 millimeter wide, light brown in color with a pinkish tinge.

The mature female.—The full-grown female scale (Plate 7, fig. 2) is usually from 2.5 to 4 millimeters long and 2 to 3 millimeters wide and usually yellowish brown in color, slightly convex and glossy. For the microscopic characters of the insect, especially as to the spiracular spines and the marginal plates, one may refer to Morrison's paper (1920) and the work of Green (1896).

The male scale.—About 1.5 long and 0.8 millimeter wide, (Plate 7, figs. 3 and 4) greenish but turns brownish when the fully developed winged adult male is about to emerge. So far as known, the adult male has not been described in the Philippines.

Specimens of the male have been reared in the laboratory from specimens collected from the field. The insect (Plate 7, fig. 1) is about 0.8 millimeter long and brownish yellow. The legs and antennae are lighter in color and like the dorsal portion of mesothorax (mesonotum) are distinctly hairy or setiferous. The antennae are 9-segmented, the third and the fourth segments

[5] The role of ants in fostering the multiplication of certain scale insects is well known. In a recent paper, Philips (1935) gives a good discussion of the subject. For one thing, ants carry the scale insects from plant to plant. The relationship is mutual. The scale insects secrete honey-dew which is food for the ants. Accordingly the scale insects also help in the multiplication of the ants.

being distinctly longer than the rest. The wings are hyaline and with numerous, short, minute setae.

NATURAL ENEMIES

The lady bird beetle, *Scymnus bipunctatus,* has been found to prey on *Puto spinosus* in the greenhouse at Singalong, Manila, but the beetle has not been observed to prey on the mealy bugs in the field.

Hymenopterous parasites have been reared from *Coccus mangiferae* Green. One of these is *Coccophagus tibialis* [6] Compere. There appears to be several species. Many specimens collected from the nests of the tree ant, *Oecophylla smaragdina,* were found parasitized, indicating that the presence of the ants is not a deterrent to the attack of the parasites.

CONTROL

In the actual control work conducted at Novaliches in 1932, 200 grams or $\frac{1}{5}$ kilo of powdered soap [7] for every one petroleum canful (5 gallons) of water was found effective against the mealy bugs, *Puto spinosus,* on young growths, killing all stages that were well wet with the spray. The concentration of 3 to 5 grams of soap per liter of water, ordinarily employed against the mango hoppers, has been found weak against these scale insects. The strong concentration (200 grams per petroleum canful of water), however, was found injurious to the flowers in bloom. It thus seems obvious that spraying should best be done on young growths to destroy the mealy bugs before they have a chance to transfer to the flowers. Perhaps spraying is possible before the flowers open or bloom, but whether or not this concentration or equivalent concentrations of ordinary soft, yellow laundry soap injures the flowers has yet to be definitely ascertained.

This concentration (200 grams of powdered soap per 5 gallons of water) was also found effective against *Coccus mangiferae* Green on mango fruits in Novaliches. This concentration, as a spray, was also used in killing the tree ants, *Oecophylla smaragdina,* which, as stated previously, are generally abundant in the mango plantation at Novaliches. The spray was chiefly di-

[6] Determined by Mr. Gahan, of the U. S. Bureau of Entomology and Plant Quarantine, from specimens sent to Dr. Morrison of that Bureau.

[7] This was of the kind first employed against locust hoppers in 1932, made by the Philippine Manufacturing Company, Manila.

rected against the nests of the ants in copious amounts to destroy not only the adults but also the young and the queens in the nests.

It is apparent that the most effective way of controlling the scale insects, if abundant and habitually injurious, is by controlling the tree ants, which have been found attending to the scale insects and apparently promote the spread and the increase of the latter, and vice versa. When abundant, these ants often travel on the ground from tree to tree. Uninfested trees can be protected from the worker ants [8] by applying tangle-foot around the trunks of such trees. The tangle-foot should be smeared around the trunk, preferably about a meter from the ground. In order to prevent possible harm to the trunk, strips of old sacks or dried banana sheath should be tied around the trunks of the trees and the tangle-foot applied on these.

Another control measure that may be employed is the use of poisoned syrup or sugar solution for killing especially the young and laying queens.

While these suggestions for the control of the ants are made, yet attention should be called to the possible benefits that may be derived from these ants, aside from the fact that in some places in the Philippines people gather the immature stages for food. In a recent paper (1935), Garcia reported that he observed *Oecophylla smaragdina* to feed on the nymphs of the Citrus green bug, *Phynchocoris serratus* [9] Donovan, and that where the ants were abundant no adult green alighted on the Citrus fruits. It is quite possible that the ants may be similarly beneficial in the control of other mango insects and observations in this regard are necessary, so the status of the ants in the control of mango pests, as a whole, may be established. It may be stated in this connection that in some countries certain ants are believed to be useful in the control of certain insect pests. In fact *Oecophylla smaragdina,* according to Groff and Howard (Clausen, 1933), is empyoyed by growers for the control of Citrus insects. However, the usefulness of the ants, as the growers al-

[8] These ants (*Oecophylla smaragdina*) annoy and bite harvesters.

[9] In a recent letter to Doctor Merino, Dr. L. B. Uichanco of the College of Agriculture, stated that the species involved is *longirostris* Stäl rather than *serratus* Donovan. This was based on a study of specimens sent him from Manila. Specimens in the Bureau of Plant Industry collection have been identified by other authorities as *R. serratus* Donovan. Dr. Uichanco added, however, that *R. longirostris* and *R. serratus* are closely related.

lege, is offset by the fact that the ants foster the multiplication of scale insects.

SUMMARY

1. Observations are presented on two nondiaspine scale insects, *Puto spinosus* Robinson and *Coccus mangiferae* Green, which have been found harmful to young growths, flowers, and fruits of mangos, especially at Novaliches, Rizal. *Coccus mangiferae* Green was first identified from the Philippines out of specimens collected from coconut but has not heretofore been reported locally on the mango. The adult made of *Coccus mangiferae* Green is figured and described for the first time, at least in the Philippines.

2. Female adults of *Puto spinosus* Robinson reared in the greenhouse on young mango plants were found to produce longer wax appendages or filaments than those in the field, thus resembling closely certain species of *Phenacoccus*.

3. *Puto spinosus* Robinson and *Coccus mangiferae* Green when present on mango flowers complicate the spraying work against the mango hoppers. The usual amount of 3 to 5 grams of laundry soap per liter of water (0.3 to 0.5 per cent) ordinarily used against the mango hoppers has been found ineffective against the two scale insects. However, the amount of 12 grams of powdered soap per liter of water, which was used for actual field control and which was found to kill the scale insects, was found decidedly injurious to the flowers in bloom. Accordingly the best time to spray against these scale insects is before the flowers appear, when they are on the young growths. They may also be sprayed on the flowers before the latter open or bloom or after the young fruits have formed—in case they are found abundant on the fruit stems or peduncles or on the fruits themselves as to cause the falling off of these.

4. The red ants, *Oecophylla smaragdina*, have been found attending to *Puto spinosus* Robinson and *Coccus mangiferae* Green.

5. It is apparent, in view of the well known mutual relationship of ants and homopterous insects, that controlling the red ants (*Oecophylla smaragdina*) will result in the control of the scale insects, if these are present in injurious numbers and thus control work is necessary. The concentration of powdered soap (12 grams per liter of water) was also found useful in killing the ants. The spray was especially directed against the nests of the said ants.

6. The use of tangle-foot or sticky tree banding material applied around the trunks of uninfested mango trees to prevent worker ants from other trees from climbing, is suggested. The use of poisoned syrups against the ants is also suggested.

7. The ants (*Oecophylla smaragdina*) are not entirely condemned in this paper. Attention is called to the possible benefits that may be derived from them in connection with the control of other mango insects, aside from the fact that in some places in the Philippines people gather the immature stages of the ants for food.

8. *Puto spinosus* has been found preyed upon in the greenhouse at Singalong, Manila, by the lady bird beetle, *Scymnus bipunctatus*. Hymenopterous parasites, of the genus *Coccophagus*, have been reared from *Coccus mangiferae* Green. The presence of the ants, *Oecophylla smaragdina*, apparently does not deter or prevent parasitism, as even some specimens of the scale insects collected from the ants' nests were found parasitized.

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Plate 1

Fig. 1. Mango leaf showing mealy bugs, *Puto spinosus* Robinson, raised on mango seedlings in the Entomology Laboratory, Singalong, Manila. Note the long wax fringes or appendages. Enlarged, about 1⅓ ×.

2. Same species of mealy bugs on young flower bud of mango and on leaves collected from the field at Muntinlupa, Rizal. Note the short wax appendages, compared with those in fig. 1. Enlarged, about 1⅓ ×.

Plate 2

Fig. 1. Same species of mealy bug (*Puto spinosus* Robinson) on young growths of mango collected from the field at Novaliches, Rizal. Note also the short wax appendages. Somewhat reduced.

2. Mango flowers infested with the mealy bugs (*Puto spinosus*).

Plate 3

Fig. 1. First instar larva (2 days old) of *Puto spinosus* Robinson taken from cultures in the Laboratory at Singalong, Manila, enlarged 14 ×.

2. First instar larva before molting for the first time under laboratory conditions, enlarged 14 ×.

3. Second instar larva, just after molting under laboratory conditions, enlarged 14 ×.

4. An adult female mealy bug collected from the field, enlarged 20 ×.

5. First instar larva, newly born, as shown under the microscope. Enlarged, about 200 ×.

Plate 4

Fig. 1. An adult female mealy bug (*Puto spinosus*). Note the groups of truncate spines along the margin. Enlarged, about 40 ×.

2. One of the anal groups of truncate spines, enlarged, about 400 ×.

Plate 5

Fig. 1. A mango flower stem and leaves showing the scales, *Coccus mangiferae* Green, collected from Novaliches, Rizal, reduced.

2. Mango leaves showing the same species of scale insects, collected from Muntinlupa, Rizal, reduced.

Plate 6

A mango fruit showing the scale insects, *Coccus mangiferae* Green.

Plate 7

Fig. 1. An adult male of *Coccus mangiferae* Green, enlarged, about 60 ×.

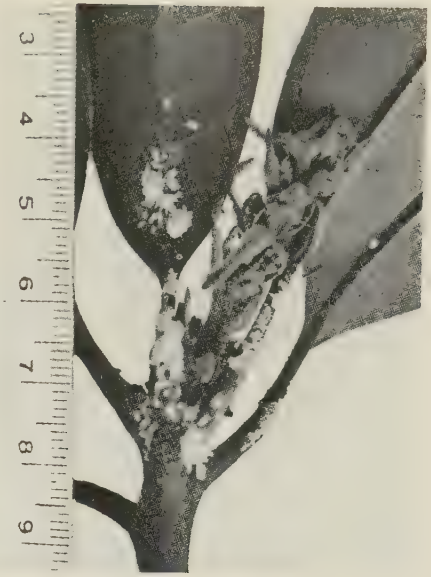
2. An adult female of *Coccus mangiferae*, enlarged, about 9 ×.

3. A male scale. Part of the scale was removed to show the fully developed adult male, enlarged, about 6 ×.

4. A complete adult male scale, enlarged, about 6 ×.

(All the photographs were taken by the Division of Publications Department of Agriculture and Commerce, Manila, and the drawings were made by the writer.)

1



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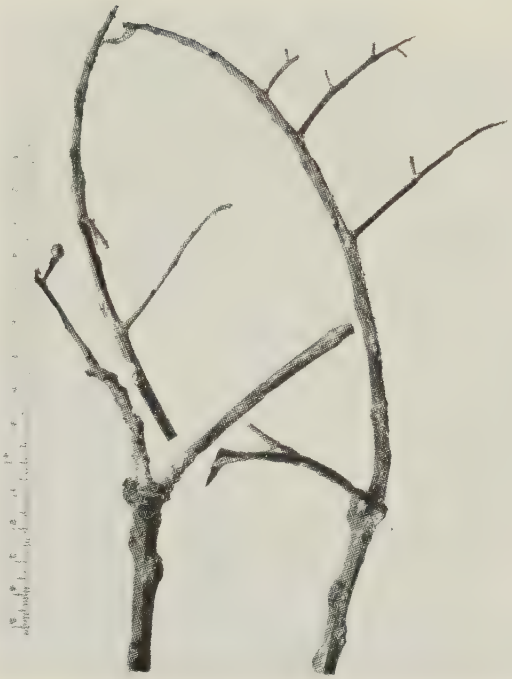

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PLATE 2.

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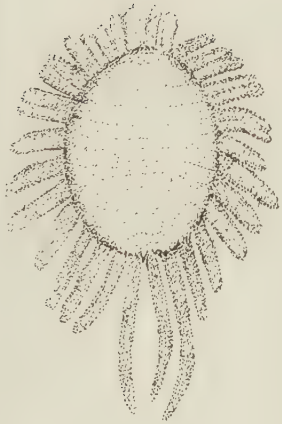

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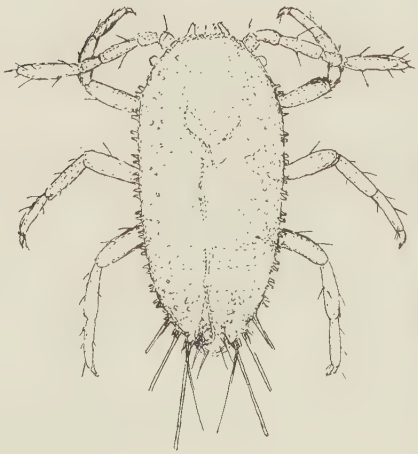

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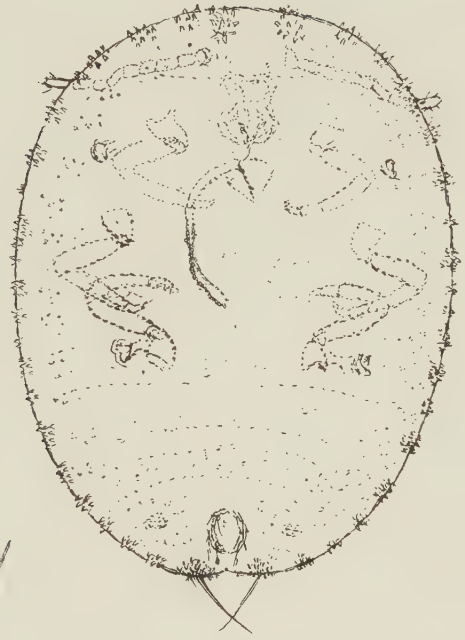

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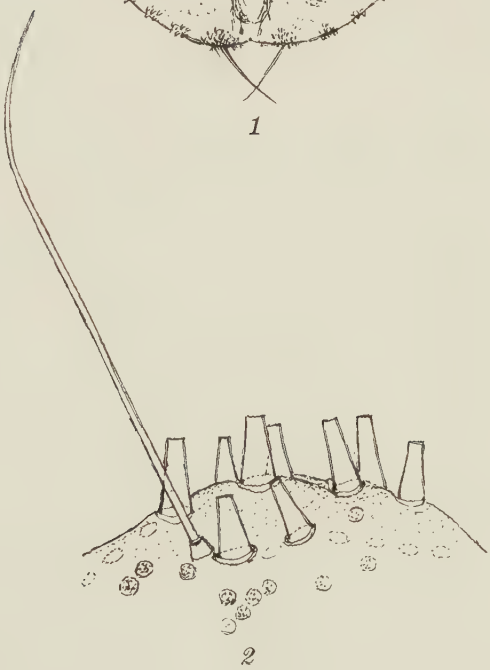

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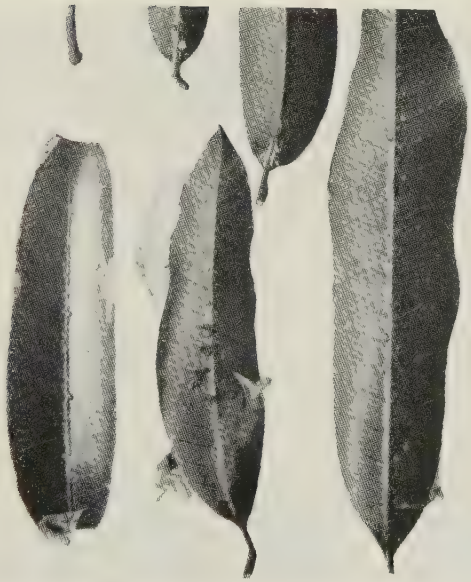

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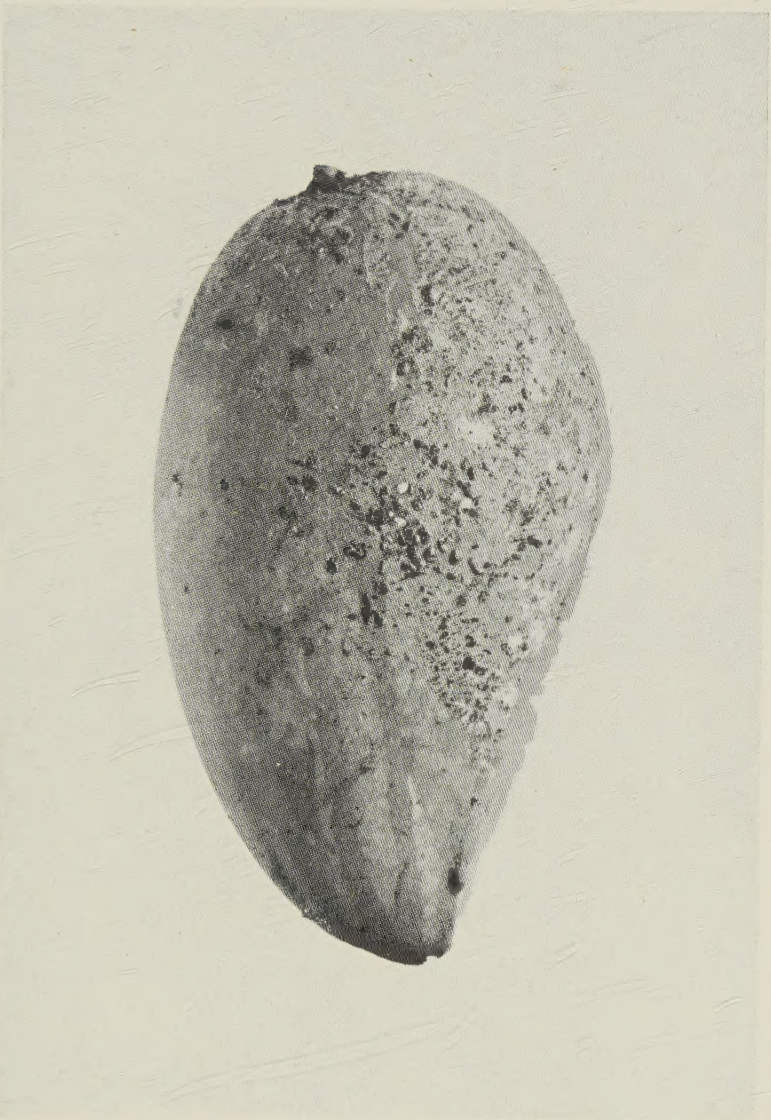

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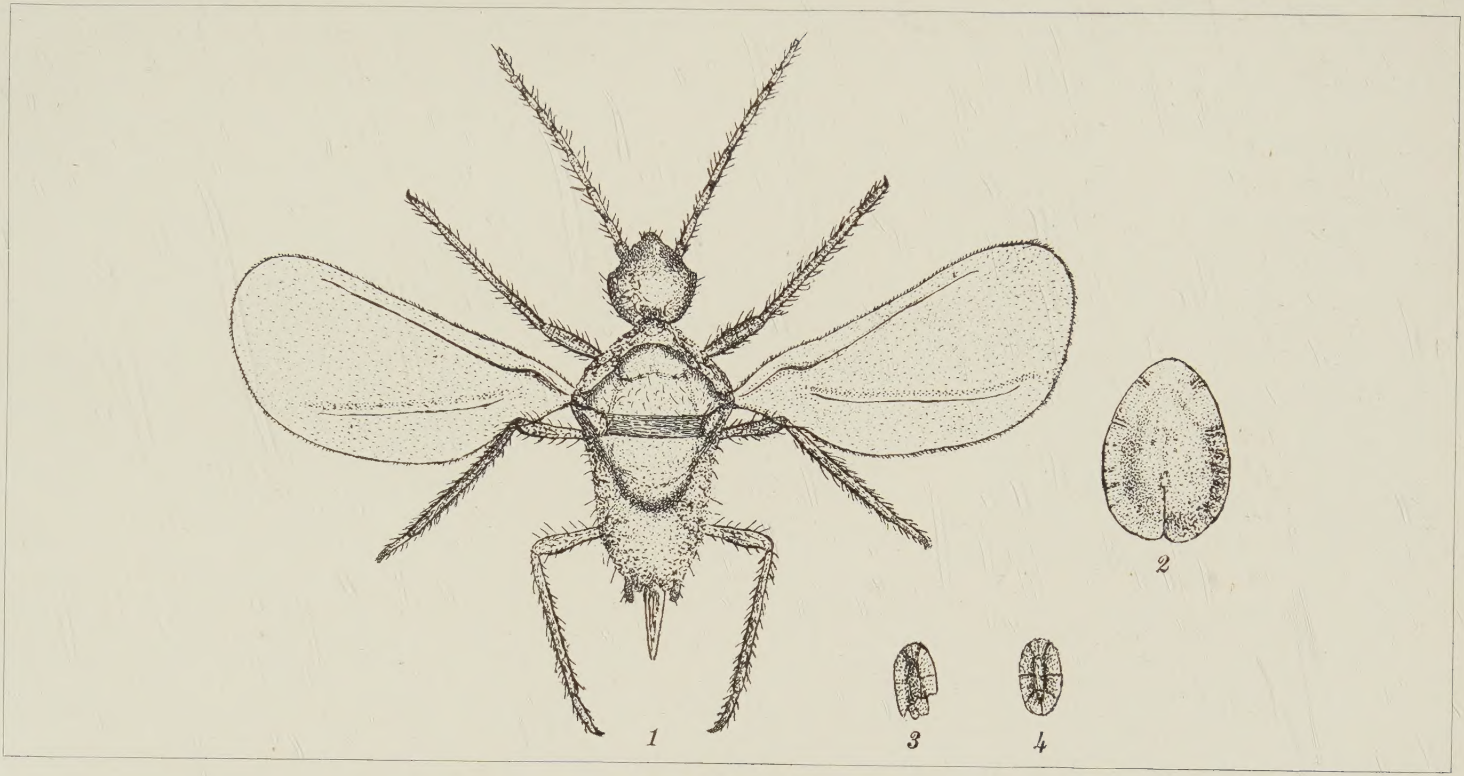

PLATE 7.